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FRANK I. MANN, Farmer

Frank Mann's Soil Book

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FRANK MANN'S SOIL BOOK

HOW TO DOUBLE THE PRODUCTION
OF YOUR FARM EVERY YEAR

THIS BOOK GIVES THE SECRETS
OF SOIL BUILDING THAT HAVE
MADE FRANK MANN'S FIVE
HUNDRED ACRE FARM THE
MOST PRODUCTIVE PIECE OF
GROUND IN ILLINOIS

A FERTILE SOIL IS THE BASIS OF
PROFITABLE FARMING

BY

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THE SCIENCE OF AGRICULTURE

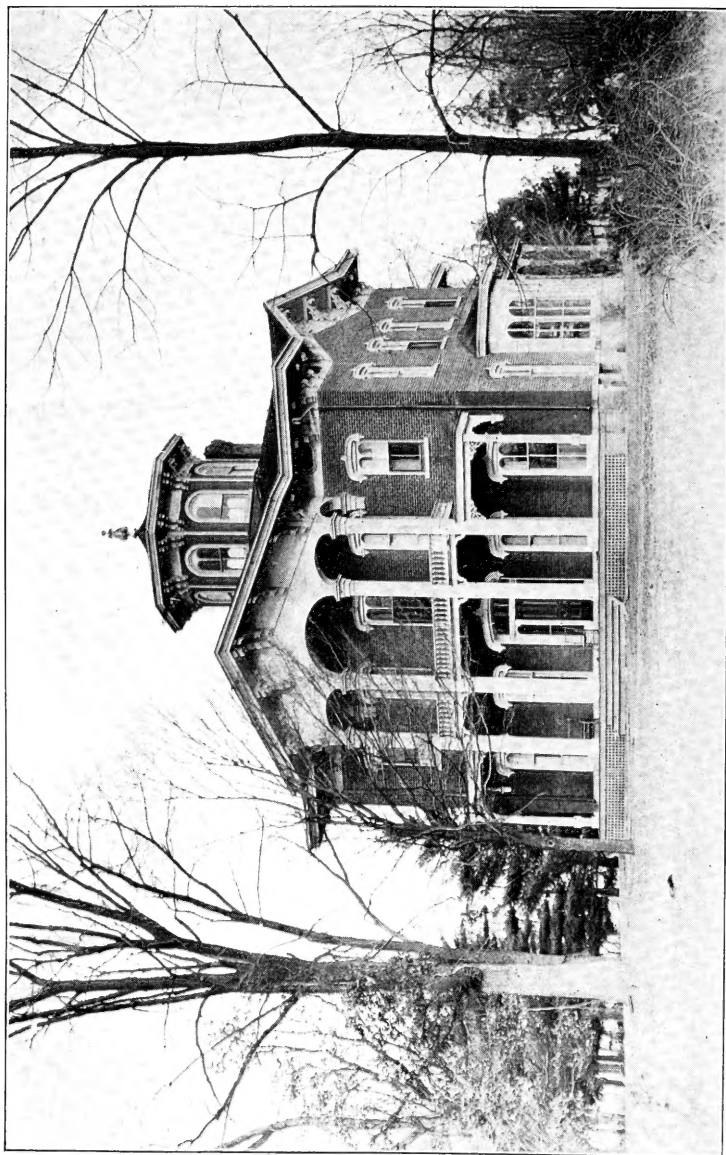
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FRANK MANN'S RESIDENCE ON BOIS D'ARC FARM.

Frank Mann's Soil Book

Part I

INTRODUCTORY

FOOD PRODUCTION MUST BE INCREASED.

It is said that history repeats itself; but we are approaching a time in the world's history that has had no parallel in the past. With population rapidly increasing; areas of tillable land practically stationary, with a slightly decreasing yield, it is possible for us to reach a time when the evils of a congested population may be greater than they ever were in Europe. The European congestion was relieved by the discovery of a new hemisphere; but all the world has now been discovered, and the future can realize no such relief. Nor can we depend on infant mortality, wars or pestilence to check the increase in population, because the scientific developments in our higher civilization tend toward less mortality and greater longevity; also to avoid wars and prevent pestilence. The remedy for us now to adopt is to grow more food on the land we have, and in a way that its productiveness may not be diminished for future use.

To grow better grain and more of it, is a worthy ambition for any man, because it is increasing the food supply. If we are to maintain our prosperity and preserve a higher civilization for coming generations an increased production on a permanent basis is necessary on the land now in use. With only small areas yet to be settled, the greater needs of an increasing population must be met through the use of land that is not now profitably productive and by a better use of the land that is now the most productive.

The question of agricultural production is of vital interest to every one. The interest manifested by railroad officials, bankers, manufacturers and merchants; the increasing appropriations by Congress and legislatures for agricultural investigation and study, is evidence that the importance of the problems of agriculture is being generally understood.

THE FARMERS' SURPLUS.

To a large extent the business prosperity of the country is dependent on the farmers' surplus crops. It is the farmers' surplus that makes possible the great transportation industry. The farmers' surplus is the basis for the business of the bankers, merchants and manufacturers. Were there no surplus from the farms, there would be no large cities, no railroads and no manufactures. Without a farm surplus even those evidences of a better civilization—the school and church—would disappear. If the farm surplus should be much decreased, such a condition would seriously affect all the great business of the country, and compel a readjustment of business methods. On the other hand, if agricultural production can be made to keep pace with population, we shall realize a business prosperity such as has not been known before.

The farmer himself is interested in the farm surplus. It is from this means that the farmer and his family are able to meet the requirements of a better intelligence, and to participate in those things which come with higher civilization. Through his surplus he must acquire the comforts of a better home, and there is no reason why the farm home should not have as many of those things which come with the modern heat, light and power as does the city home.

In a fertile area, where the surplus farm products are abundant, and have been abundant for a long time, we are liable to assume that such a condition is normal and permanent, and congratulate ourselves that we do not live in a poor country. But visit some of those areas that were once fertile but are now sparsely inhabited by a depreciated population, where the surplus products are almost limited to small sales of tobacco or poultry. Would not such a visit stir a deep resolution to avoid such systems of farming as had caused this soil depletion?

When the writer "took to farming" it was with a firm belief that before many years the ratio between food production and consumption would so widen that the law of supply and demand would operate to establish such prices as would make farming profitable. Some rather serious conditions have been met during that time. There have been times when crops were sold at a price that was less than the fertilizer value of the crop; prices so low that fertilizer factories could have worked grain crops into mixed fertilizers and sold them at a profit at fertilizer prices. However, we have now reached a time when the ratio between food production and population

causes prices that will justify profitable agricultural production and permit of permanent soil treatment, notwithstanding the numerous handicaps that have been placed on agriculture by legislation and trust combinations.

The ratio now existing between farm products and population, and the prices that prevail because of this, is probably not far from the best ratio that could exist. Under this ratio, the farm prices will justify a development of both the farm and the farmer; and such prices are no great burden on those not engaged in agriculture. Any further great widening of the ratio would be out of balance, and would be reflected in the general prosperity and happiness of the whole people. Likewise, if the ratio should be greatly diminished it would bring back the period of agricultural poverty which would also be reflected in the general prosperity of the whole people.

When we consider how easily the agricultural production can be increased it looks as though the food production might more than overtake the increasing population, but when we consider the slight difficulties attending increased production as well as realize the lethargy of so many land owners, we must conclude, that, as a people, we will be fortunate if the production merely keeps pace with the increasing population.

While the agricultural interests are now in a fairly satisfactory position, the same is not universally true regarding the manufacturing interests, and the farmers can look with complacency, at least, at the squirmings, under popular wrath, of many of the over-developed-in-capacity, so-called, business interests, to adjust themselves to normal demand, by combinations to limit production and fix arbitrary prices.

FAULTS IN DISTRIBUTION.

Much attention has been given for a few decades to the development of railroads and other means of transportation, except the country roads, and the problems of transportation have been quite well settled; so that transportation is now probably a minimum charge in the distribution of products. There are, however, other factors of distribution that need to be given consideration looking to a solution. These factors in distribution relate chiefly to the "middleman," his duties and his compensation. It is outrageous that people in cities are compelled to pay 100 or more per cent. over the country price for country products, and much of the so-called high cost of living is due to the crude and unsystematic methods used in



FIG. 1—FRANK MANN AT WORK IN HIS DEN.

the general system of distribution. The country price for country products is an open book and can be readily ascertained, so that buyers in the cities can know what advance they pay over the country price. But when the farmer buys a manufactured article he frequently pays from 100 to 1,000 per cent. over the cost, for he has no way of knowing the cost. One of the next problems for the people to solve is that of economical distribution of products.

As the increase in food production is necessary for business prosperity and for the preservation of civilization, it is the dominant universal problem.

HOW CAN INCREASED YIELDS BE SECURED.

The art of agriculture is old. Cain and Abel were the first farmers; one being a grain and the other a livestock farmer. From that time till now the art of agriculture has been practiced in every country and in every climate. All the different methods that could be developed by the art of agriculture have been practiced. Different methods of plowing; deep, shallow, and subsoiling, and different ways of turning the furrow. Different methods of seeding, and different depths of planting, and different amounts of seed. Rotation of crops in every possible combination, and for every possible purpose. Selection and improvement of seed for specific purposes. Adaptation of certain crops to certain kinds of soil. What more can be included in the art of agriculture? The ancients knew all of these; but the production was not maintained nor the fertility of the soils preserved.

The general claim is frequently made that nothing more can be done to produce large crops than good farming; that is, to use the best methods in the art of agriculture. Much of the advice that is now given for growing better crops is related to these practices known to the art of agriculture, and to which not much science has been applied. It is frequently held that certain methods relating to plowing, planting, seeding and breeding were the most efficient means of growing the largest crops. One man may claim that deep plowing is the principal requirement for a large crop; while another may hold the same view with reference to shallow cultivation. There are still radical advocates of all these methods, each one contending that his scheme is the essential thing.

In view of the hundreds of years of experience in the art of agriculture, it would be remarkable if it were left to this day to discover that increased production could come from any of

these methods that have been so long practiced. These questions all relate to the art of farming, and the fact that they have been in controversy ever since there was a history of agriculture, is sufficient proof that no one of them nor all of them can be considered as essential requirements for increased production on a permanent basis; but that each contention meets times and conditions when it is the greatest temporary relief, and hence the variety of opinions concerning the different customs. The improvement of crops by breeding has also been advocated as the means of securing higher production; and another "new" method strongly advocated as being the only requirement is the thorough testing and grading of seed to insure the most perfect stand.

WHAT IS THE LIMITING FACTOR IN CROP PRODUCTION?

If the limiting factor in crop production is some fault in the practice of farming, then when the fault is corrected the crop should give response. If the fault was in the method of plowing or cultivation, when the right method was practiced the maximum crop would be realized. If small crops were due to a poor stand, then a good stand would be the remedy; if they were due to poorly bred seed, then well-bred seed would be the remedy. But when all these faults are corrected, and the best methods practiced throughout, we still fail to obtain any large increase in yields.

If all known methods of soil tillage and crop management fail to grow a maximum crop then the trouble must lie in the soil itself. What is the need of having a perfect stand of corn when half a stand is equal to the productive capacity of the soil? What is the use of planting highly bred seed when scrub seed will produce as much or more than the soil will properly feed? What is the use of planting seed enough to grow 100 bushel crops when the soil will furnish only food enough for 50 bushels? What is the use of using the most advanced methods known in the art of agriculture when ordinary methods will meet the maximum soil capacity?

Though no method of farming can secure yields above the capacity of the soil to feed, it is easy to hold yields below this capacity of the soil, by practicing radically wrong methods. Where the yields are held low because of some error in the methods used, such error should be ascertained and rectified.

The writer does not wish to discredit the art of farming, nor decry the development of the best methods that can be

used, but it should be well understood that largely increased production can not come through the adoption of any modification of methods known to the art of agriculture. It is only after the productive capacity of the soil has been increased that the best practices in the art of farming will prove of their full value. Then there will be need of well-bred seed, perfect stands and more efficient methods.

WHAT IS THE NATURAL CAPACITY OF THE SOIL?

Has any reader of this book ever grown or known of being grown on any normal, even virgin soil, except black clay loam, a crop of more than 60 bushels of corn or an equivalent in other crops, under any method that could be used, when plant food had not been added in some form, either as clover, manure or pasture, or fertilizers? Many farmers have done this when plant food had been applied, but without some addition of plant food it has rarely if ever been done. This indicates that the problem of high production is in supplying plant food and not in modifying methods of farming.

On Bois d' Arc farm during the last 30 years there have been tried many of the different practices that have been recommended for increasing yields: deep, medium and shallow plowing; subsoiling over 20 inches in depth; various methods and tools in cultivation; different methods in seeding; early and late planting; thick and thin seeding; and no great increase above the usual yields was ever secured because of any of them. If the method employed was at any great variance from well established practices the yield has sometimes fallen below the normal. **Never until the soil was given intelligent treatment with reference to feeding the crop were largely increased yields secured.**

MOISTURE A LIMIT TO CROP YIELDS.

It is frequently stated that the size of the crops is usually limited by the amount of rainfall. This may be the case, but at what yield does this limit operate? The season of 1911 was the driest known for many years in many parts of eastern Illinois, where the entire dust mulch made in May was not moistened until about September 1, when the crop was practically mature. Wheat that yielded from 20 to 35 bushels had the same rainfall as that yielding 52 bushels; oats that yielded 80 bushels had no more rainfall than those that yielded 40 bushels; corn that yielded 70 bushels had no more rain than the corn that yielded 30 bushels. Moisture may limit the crops, but where is the limit?



FIG. 2—FRANK MANN IN HIS
CORN FIELD.

Part II

THE SCIENCE OF AGRICULTURE

The art of agriculture is old, and consists of those practices which long experience has considered worthy of adoption. The science of agriculture is new, and consists in the application of the sciences of mathematics, chemistry, physics and biology to agriculture. When a load of corn is weighed the amount of corn is computed by the science of mathematics. The science of mathematics has been in general use a long time, and no one questions its truth. The truth of the science of chemistry is as well established as the truth of the science of mathematics, and is entitled to the same confidence. Not until the last few years has there been much science applied to agriculture.

CROPS NOT MADE OF NOTHING.

One of the first fundamental truths established by chemical science when applied to agriculture was that "crops are not made out of nothing," but that certain chemical elements are as necessary in the growth of crops as are heat and light, and that some of these elements must be fed to the plants through the soil. What they must be fed and the manner of this feeding has now been well worked out, and is being exemplified on many demonstration fields in different parts of Illinois and on many types of soil.

Feeding crops involves two propositions; one, supplying the needed chemical elements; the other, making these elements available to the plants.

Before plants can use the elements of plant food that may be in the natural soil, or that may be applied in an inert form, certain bio-chemical changes (chemical changes caused by bacteria) must have taken place that will make these elements available to the plant's use.

There are different ways in which this availability can be procured, but the one that should have our attention in practical agriculture comes from the activities in the decomposition of organic matter. A soil might contain large quantities of all the elements of plant food, but without some process of

liberation by which this plant food could be made available, it would not be a fertile soil. Active organic matter is the life of a soil, literally, as besides the chemical changes necessary, it provides the medium for the development of the necessary bacterial life.

COMMERCIAL FERTILIZER NOT NEEDED.

A very common substitute for the liberating effect of decomposing organic matter is the use of caustic substances, either in mixed fertilizers or by themselves, such as landplaster and burned lime. The use of such materials has no place in a permanent system of maintaining soil fertility as their effect is only one of stimulation, and tends to deplete the soil of its fertility to a greater extent.

The most common use of these caustic materials comes from using the mixed commercial fertilizers, which contain small amounts of plant food to give the plant a start, and include also caustic substances to force enough plant food from the soil to complete the growth of crops. It is fortunate, indeed, that the people of Illinois have been so fully instructed in the principles of permanent fertility that very little of the complete mixed commercial fertilizers have been used in the state, and without a doubt they never will be used. The objection to such fertilizers is their use as substitutes for the elements of plant food, and the excessive cost of the small amounts of plant food contained.

ACTIVE ORGANIC MATTER NECESSARY.

Active organic matter is any form of vegetable or animal matter that will decay in the soil: manure of all kinds, stubble, stalks, weeds, clover, cowpeas, straw, etc. Crop residues (cornstalks, straw, stubble, etc.) do not afford sufficient organic matter for high fertility, and it is essential that more than this be supplied. As nitrogen is the most largely used element of plant food, and as special crops must be grown to supply nitrogen, these same crops may be depended upon to supply organic matter. Then the maintenance of both nitrogen and organic matter becomes almost a single problem, as legumes serve both purposes.

To some extent organic matter can be used as a soil stimulant, as the acids formed in the decomposition of vegetable matter have the same effect as those used in mixed fertilizers. The intelligent use of such acids is legitimate when used for their proper purpose. The fault comes from their excessive use as substitutes for plant food. Crop residues or non-legumin-

ous crops that may be grown for their organic matter, do not increase the nitrogen supply in the soil, as the nitrogen contained in them was but recently taken from the soil. Growing rye, rape, buckwheat or any other ordinary crop for the purpose of plowing under is meritorious, but its true action as a stimulant should be understood, and no dependence placed on these crops as carriers of any new supply of plant food.

Manure has to some extent the same stimulating action, especially where the nitrogen of the manure is not urgently needed by the crop. Here some of the action of the manure is its liberation of the mineral elements from the supply in the soil, so that after a time heavily manured land becomes out of balance in the plant food supply, and may give large growths of straw and stalk, without a grain yield in proportion. Manure without bedding included with it is not a very good carrier of vegetable matter, and the amount of manure required to maintain nitrogen enough for large crops, is not sufficient to furnish enough organic matter, if the manure is made from highly digested food. Nor does enough humus result from its active decomposition to keep the soil in good physical condition. This is indicated by a garden on Bois d' Arc farm where high fertility has been maintained in this way for over forty years, but the soil is not in good physical condition.

Clover, also, has a similar stimulating action, and on the rich prairie land of the corn belt, much of the increase in crops after clover, comes from its ability to liberate minerals from the soil. On Bois d' Arc farm clover was established as a crop in rotation in 1879. For a few rotations the effect of clover was realized in the crops, but the time came when the crops fell below normal expectations. About the same growth of stalk and straw was secured, but the effect of having forced the minerals from the soil more rapidly with the clover, was finally shown in reduced production of the grain itself. This liberating effect of clover is just what is desired, but it should be remembered that if the minerals are not kept supplied the effect of the clover is to wear out the soil more rapidly.

In some places there is a growing tendency to use potassium salts on soils not at all deficient in potassium, because they give increased yields. Here again, the effect is one from stimulation and cannot be depended upon for permanency. On soils that are deficient in organic matter it may be legitimate to use some caustic salts as a temporary expedient until organic matter can be added to the soil. But it must be remembered that the supply of nitrogen, vegetable matter and phosphorus will be depleted long before that of potassium.

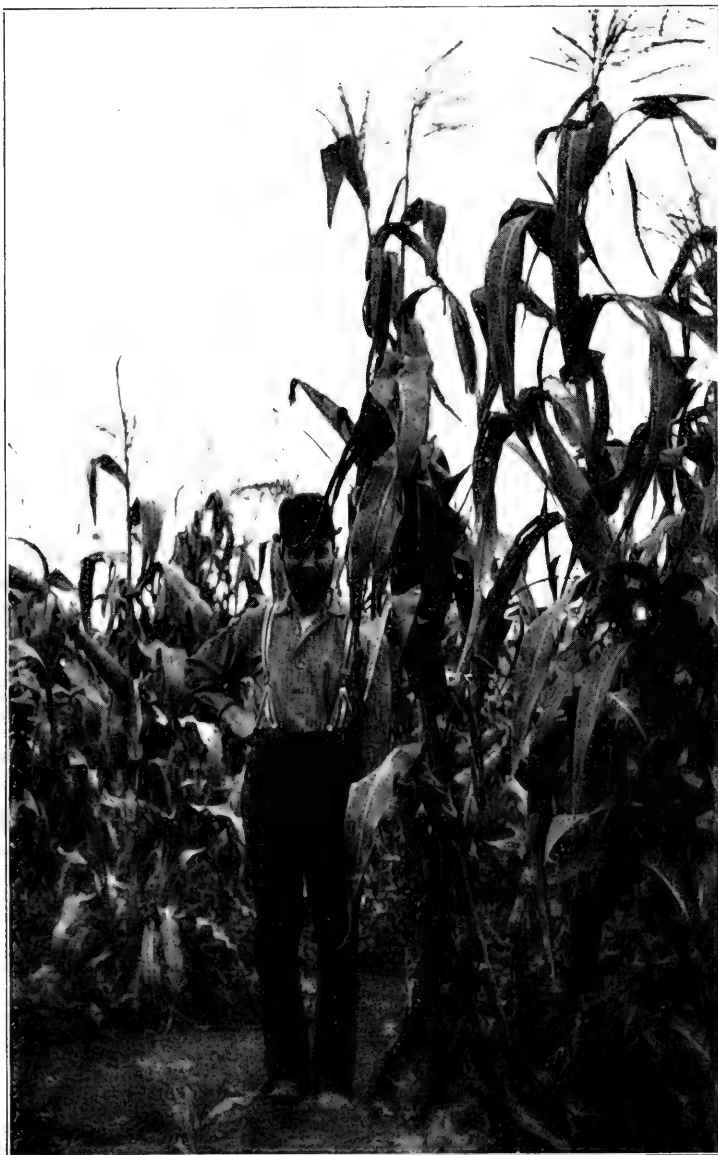


FIG. 3—PLENTY OF NITROGEN BUT NO PHOSPHORUS SUPPLIED.
YIELD, 50 BU. PER ACRE

THE GREATEST PROBLEM OF SOIL FERTILITY.

The greatest problem in permanent fertility is to maintain the organic matter with its nitrogen, because of the large losses from its decomposition, and from the fact that great quantities cannot be supplied at any one time. Vast quantities of mineral elements can be applied at any one time, if in an inert form, and the only limit would be one of dollars and cents. But to maintain organic matter and nitrogen requires skillful use of rotations and constant attention to necessary details. It requires money for the former, but it takes brains for the latter. It is not profitable to apply excessive quantities of organic matter at any one time, as some of the elements of plant food may be liberated faster than they can be used by the crops and become lost; or plant food may be liberated at a time when there is no growing crop, and some of it be lost, though this loss is frequently prevented by the growth of weeds which seem to adapt themselves to this purpose exceedingly well.

There is also an interference with other soil functions when excessive amounts of vegetable matter are applied at one time, especially when dry conditions follow. When large amounts of vegetable matter are to be plowed under, it is beneficial to cut it up well with a disk and mix it with the soil as much as possible before plowing. This largely prevents the layer of vegetation at the bottom of the furrow, which will interfere with the normal movement of moisture in the soil.

Because of the perishable nature of vegetable matter, it is absolutely necessary to save to the utmost the annual crop residues, and all straw and stalks removed should be conscientiously returned to the land. If straw is not used for bedding or food return it to the land at once and do not wait for it to rot down. The rotting action is needed in the field.

The raking and burning of corn stalks ought to be stopped by public sentiment if not by public law. A heavy growth of corn stalks can be returned to the soil without seriously affecting any farming operation. They can be twice cut if necessary with a stalk cutter at an expense of but a few cents per acre. If cut when the stalks and ground are in right condition there will be practically no annoyance from them afterwards. The value of the plant food in corn stalks can be easily computed, but this value may be small as compared to their value to land much deficient in vegetable matter.

Expressions of regret are sometimes heard that the corn stalks cannot be utilized, instead of permitting them to go to

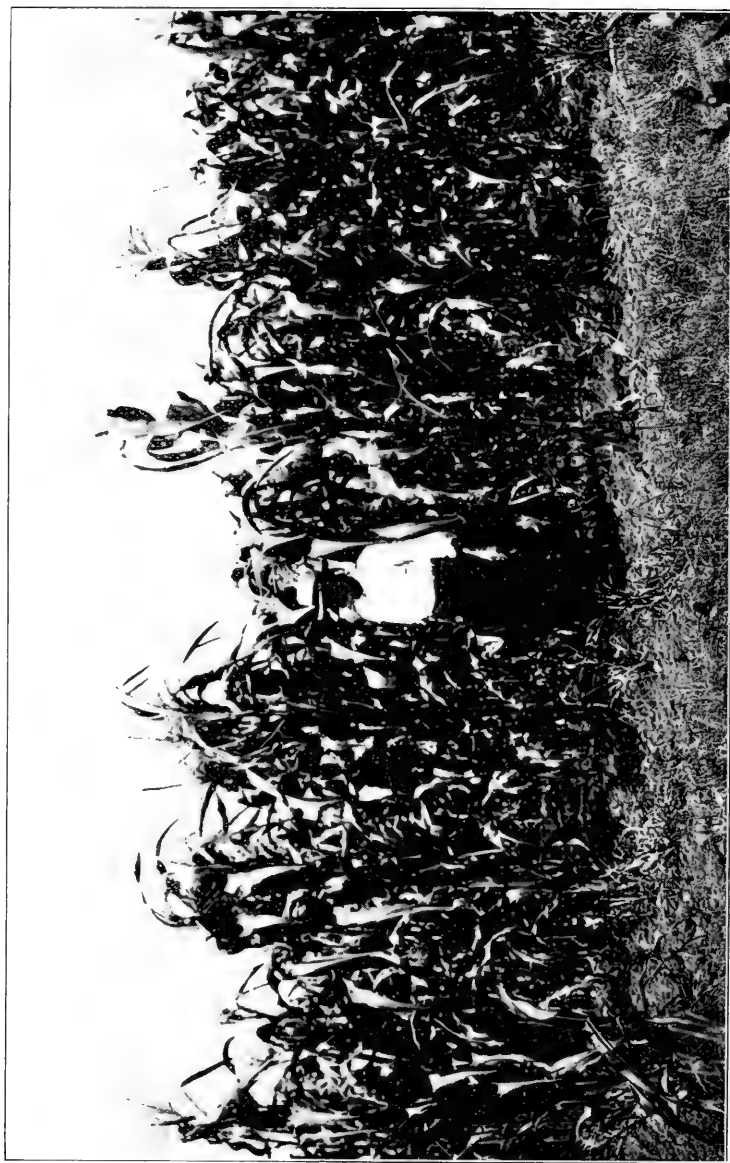


FIG. 4—FRANK MANN'S CORN FIELD JULY 9, 1911. THIS FIELD HAS RECEIVED REGULAR SOIL TREATMENT FOR SEVERAL YEARS. YIELD 1911, 70 BU. PER ACRE.

waste. The western farmer has been severely scored by a certain class of critics because he permits the stalks to remain in the field, and they figure a loss therefrom of immense proportions. Various schemes have been advanced by which the great loss could be prevented, and these schemes have varied from making paper to the manufacture of gun boats out of the stalks.

This belief that corn stalks are wasted when left in the field does not take into consideration the effect of corn stalks when added to the soil. The value of this is far greater than could come from any of the commercial projects ever proposed. It is hardly possible that there can ever be any commercial proposition which can recover as much value from corn stalks as is already realized by adding them to the soil. Were it not for the stalks and weeds that have been returned to the soil, the productive capacity of worn soils would be much less than it is now.

While nitrogen is the measure of vegetable matter in the soil it may not express the real value of such vegetable matter. The nitrogen may be contained in well-decayed vegetation that does not have the power to liberate much plant food. It is active decomposition that is needed. In the case of clover the decomposition is so rapid and complete that before a rotation has passed the decomposition is so nearly completed as to be inadequate for liberation purposes. On the other hand, crop residues decay slowly and when used in connection with clover make a valuable combination.

Sub-Soil Organic Matter.

A fact of considerable value that comes from growing deep-rooting plants in the rotation, is the development of the root-system in the subsoil, though this varies with different subsoils. It is common on Bois d' Arc farm, when laying tile, to find the subsoil permeated with clover roots to a depth often of five feet. These deep roots contain more or less plant food that may be used by succeeding crops; they increase the porosity of the soil; they improve the efficiency of drainage; their decomposition furnishes humus which increases the moisture-holding capacity of the sub-soil, and they tend to equalize capillarity within the soil. To secure this deep growth of the root system it is necessary that the clover be growing thickly on the ground. When the clover is thin the roots spread out at shallow depths, but when thick will grow with erect tops and deep roots. The favorite rotation crop on Bois d' Arc farm is

a mixture of red clover, alsike clover and timothy, with the red clover largely predominating. In this combination more growth can be secured than with any of them alone, and there is a greater development of root systems, with the red clover roots occupying the deeper root zone, the alsike roots in a shallower zone, and the timothy roots in the surface. As timothy decays more slowly than clover, decomposition goes on for a longer time, and being more woody than clover it adds more humus when decayed.

The difficulty of increasing the supply of vegetable matter in worn soils makes it of great importance to maintain the supply in lands that now have a fair amount. It is much easier to produce vegetable matter where there is a good supply already, than to build it up after the vegetable matter is depleted. The vegetable matter in the soil of Bois d' Arc farm and many other farms in the corn belt could not be duplicated in forty years if four tons of clover were grown and plowed under every year, and there was no loss during the period. This shows how great is the task of building up a soil in vegetable matter, and should prompt every land owner to do all that is possible towards maintaining the supply by frequent additions.

How Much Vegetable Matter?

Apply all the crop residues that is possible, and in addition, grow enough clover or some legume to supply as much or more nitrogen than is removed by the crops.

Remember that plants, like animals, must be fed; that animals might starve within sight of a crib of corn and a mow full of hay, provided they were locked up; that plants can starve in the presence of great quantities of plant food, provided they are locked up; and that the function of active organic matter is to unlock the elements of plant food.

HUMUS.

Though the term humus is frequently applied to all vegetable matter in the soil, the better use of the term is to denote only the well decayed vegetable matter. After a time, any vegetable matter becomes so thoroughly decomposed as to be without definite form, or suggestion as to its original source, and becomes also practically inert, or inactive. This is humus. The value of humus comes largely from its physical effects on the soil. It renders the soil dark in color, thereby making it warmer. It makes it more porous, which permits better aeration and nitrification. It increases the ability of the soil to

accumulate and retain water at a time of rainfall, thereby helping to overcome the effects of drouth. It tends to increase capillarity when low, and decrease it when too high, thereby acting as a regulator of the moisture supply. It makes plowing and all operations of tillage easier and more efficient and it makes the soil pulverize more readily and helps in the formation of a good seed bed.

Humus, drainage and plant-food are the principal factors necessary to overcome adverse weather conditions. Crops on well drained land supplied with plenty of plant food and humus, can laugh at almost any local weather conditions. Corn stalks and other crop residues are a valuable source of humus, and they should be carefully saved for this purpose, aside from their plant food value.

NITROGEN.

No method of soil stimulation or plant food liberation can maintain permanent fertility unless a supply of the elements of plant food is maintained. Of all the chemical elements that are necessary for plant growth, only three require consideration on normal soils. These are nitrogen, phosphorus and calcium, though limestone might be considered as a necessary amendment to neutralize the surplus acids formed in vegetable decomposition. It also furnishes calcium as plant food.

Nitrogen is the element most largely used by plants, and it exists in the greatest abundance; the greatest supply is in a free state in the air, however, and it is hard to capture and difficult to hold. Most of the common commercial explosives are combinations of nitrogen, which under certain provocations will return to a free state with a "bang." While nitrogen does not leave the soil so suddenly, its loss is sure and steady and requires frequent additions to maintain a supply.

The soil nitrogen exists only in the organic matter, and the problem of maintaining nitrogen and organic matter is much simplified by this fact. It was held by some agricultural writers until recent years that the time limit of life on the earth was the amount of nitrogen contained in combination with organic matter, and when that became exhausted all life must cease to exist. The discovery that nitrogen could be acquired from the air through the bacteria that live on the roots of clover and other leguminous plants was probably the most important application of science to agriculture that has ever been made. It provides an intelligent method of maintaining nitrogen, and one to which the science of mathematics can be applied as a measure.

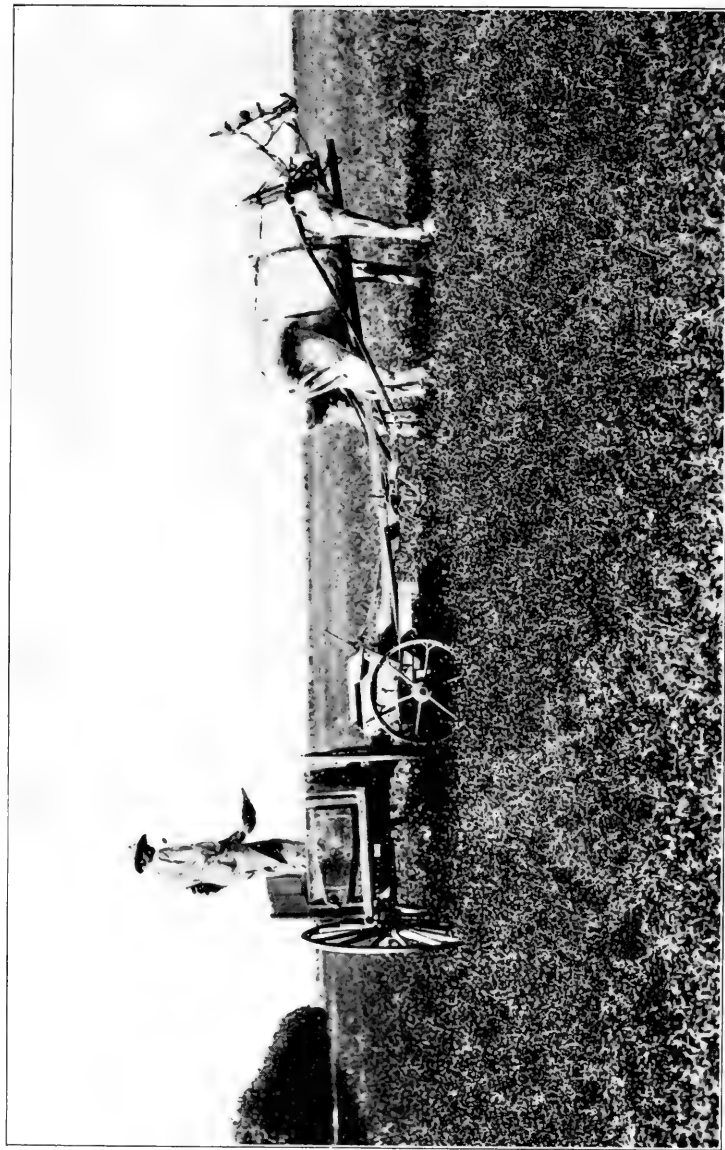


FIG. 5—ROCK PHOSPHATE IS HAULED DIRECT TO THE FIELD AND SPREAD AT ONCE.

How Much Nitrogen?

By knowing the crop requirements of nitrogen, and also knowing how much nitrogen can be added with legumes, it can be estimated how much legume growth is necessary to provide sufficient nitrogen. It requires one and one-half pounds of nitrogen to grow one bushel of corn, two pounds to grow one bushel of wheat, and one pound to grow one bushel of oats, though practically one-third of these amounts may be returned to the soil in the crop residues.

One ton of clover hay contains 40 pounds of nitrogen; one ton of cowpea hay, 43 pounds; one ton of alfalfa, 50 pounds. This is not taking into consideration the nitrogen that may be in the roots of these crops. These amounts must not be considered as the amounts of nitrogen that are sure to be added by growing these crops, because a part of it may come from the supply already in the ground. Any legume crop should be considered as having used the available soil nitrogen before resorting to bacterial nitrogen.

Soil that will supply nitrogen for a 50 bushel corn crop will supply the same amount to a legume crop, which is enough for more than one ton of hay. Where not more than a ton to a ton and one-half of legumes are grown, but little nitrogen, if any, is being added, and any beneficial results that may come from such a crop is the action from its decomposition. This is a very common condition, and some of those who are growing such small crops of clover will insist that they are keeping up fertility by growing clover. Even in acid soils legumes will grow up to the capacity of the soil to furnish nitrogen, and because small crops of clover will grow is no sure indication that the soil is not acid.

Clover the Best Legume.

Of all the legumes for supplying nitrogen, the best are the clovers, where they can be depended upon. They fit in the rotation the best, have a better root development, are easiest cared for as hay, and are the easiest seeded. It is a sorry day for any farm when conditions become such that clover usually fails.

Nature left such a vast quantity of vegetable matter in the dark prairie soils that nitrogen is not usually the first limiting factor in crop production on these soils. The vegetable matter is, however, getting so much decayed that such soils respond quickly to the action of fresh organic matter. Nitrogen is becoming deficient on the high spots on the best

farms, and these high thin spots are enlarging rapidly and becoming more numerous. On Bois d'Arc farm clover has been grown in a four-year rotation for about thirty years, but this has failed to maintain enough nitrogen on these thin spots, and on the rest of the land the crops are still drawing to some extent on the original natural supply. The attempt now is being made to increase or at least to maintain the nitrogen, where deficient, by applying manure and by plowing under the total hay crop. It may be maintained in this way for a time, but the time is not far away when so much of the land will be deficient in nitrogen as to require the growth of more clover and the adoption of a different rotation.

The mere growing of clover or other legumes does not add nitrogen to a moderately productive soil. It is only by returning the growth to the soil that any nitrogen can be added to it. Where the crop is sold, or fed and the manure not returned, but little, if any, nitrogen is added, and when very small crops of legumes are grown the nitrogen may be diminished. Even when fed and the manure returned, there is considerable loss of the nitrogen, both from what is retained by the animals and from natural losses from the manure before returning it to the ground. Because of these losses legumes must be grown in any live stock system as well as in a grain system, if the nitrogen is to be maintained. The permanent and ever-present problem of soil fertility will be to maintain a supply of nitrogen in the soil for large crops.

PHOSPHORUS.

Phosphorus is the mineral element of plant food to which we need to give direct attention in soil fertility, on normal prairie soils. Though there may be other elements needed, they will be cared for incidentally in other operations. Of all the factors that enter into permanent productiveness, that of phosphorus is the most easily applied. It has but to be bought and applied, and enough for many years can be applied at one time, without danger of any appreciable loss, except by the removal of crops. In the dark prairie soils where large amounts of nitrogen and vegetable matter were placed in the ground while still in a state of nature, phosphorus has usually been the limiting factor in crop production ever since the land was tilled. In fact, it is probable that phosphorus was the factor which limited the growth of grasses in the wild prairie. The writer, when a boy, while herding sheep and cattle on the wild prairie of McLean county, often wondered why the growth of wild grasses on

the low ground was waist to shoulder high, and on the high ground was but shoe top to knee high. And not until some analyses were made of these soils and several years' experience was obtained in applying phosphorus on these same soils, was any satisfactory solution reached. As the lack of phosphorus limits the growth of legume crops now, it is fair to suppose that there was the same limit to the legume growth in the wild prairies, and it was the wild legumes that supplied the nitrogen to make our virgin soil. Hon. Joseph Carter, of Champaign, identified 56 species of wild legumes on the prairies of McLean county when he studied botany at the Normal University.

Notwithstanding a large amount of nitrogen in a soil, if the supply of phosphorus is small, the crop yields will be limited to the supply of phosphorus liberated. A soil may contain enough nitrogen for 100 bushel crops, but if the phosphorus content is sufficient for only 50 bushel crops, the yields would stop at 50 bushels, and much of the nitrogen not used would be lost. The nitrogen that has been lost from the prairies of the corn belt, because it was not balanced by phosphorus, is fabulous in amount. The process is still going on wherever the soil is richer in nitrogen than it is in phosphorus, compared to crop requirements.

There is still a most wonderful opportunity to increase crop production by balancing an excess of nitrogen, which is still contained in much of the rich land of the corn belt, by supplying phosphorus. Because of being better supplied with phosphorus the plants are enabled to use a large part of the nitrogen that would otherwise be lost, and there is a gain in production from this use of nitrogen as well as from the phosphorus itself. There is yet land in the corn belt that contains nitrogen enough for 100 bushel crops, but that is yielding but about 50 bushels, because of the phosphorus limit. No other reasonable investment can make such large returns as does this kind of soil treatment.

It is still believed by some that the best corn lands do not decline in fertility, and this idea can be explained to some extent in this way: An excessive amount of nitrogen can not produce crops above the phosphorus limit. Some of the prairie soil, in its virgin state, contained nitrogen enough for probably 150 bushel crops, but the phosphorus limit was about 60 bushel crops. The nitrogen could be decreased, by natural losses, to a 100 bushel capacity without materially affecting the yields, as the phosphorus content declines very slowly. The nitrogen loss can be carried down to only a



FIG 6—A HOME MADE SPREADER IS THE BEST MEANS FOR DISTRIBUTING THE PHOSPHATE.

50 bushel capacity, or the phosphorus capacity, before there comes any great decline in yields. When the nitrogen capacity becomes less than the phosphorus capacity, the decline in productiveness will be sudden and rapid. This condition will soon be reached by the rich lands of the corn belt.

The Function of Phosphorus.

The function of nitrogen lies in the growth of leaf and stalks of plants; that of phosphorus is in the growth of the grain, and especially in the vital parts of the grain. The color and rankness in the growth of plants is some indication of the nitrogen supply, but only when phosphorus is very deficient will its addition be particularly noticeable in color and growth, except in legume crops. As the principal effect from phosphorus additions is in the grain, it takes the scales to determine its efficiency. Measure the ground and weigh the grain.

Sources of Phosphorus.

When dependence is placed on organic matter for the liberation of plant food, phosphorus can be used in the cheapest form in which it can be procured. This is the ground rock phosphate. In this phosphate the phosphorus is contained in varying amounts and in combination with other substances. The phosphate is inert; that is, it has no power to decompose itself, so as to liberate the element phosphorus. Phosphate has no caustic action on the soil, and a person may get his eyes, nose and ears full of it without any injurious effect, which is proof that any amount of it cannot harm a soil. Another source of phosphorus is bone meal, which contains about the same percentage of phosphorus as does a good grade of rock phosphate. In the bone meal the phosphorus is more easily liberated, and on soils quite deficient in organic matter it may sometimes be preferable to use bone meal, though it is a much more expensive source than rock phosphate.

How to Buy Phosphate.

The phosphate rock contains varying quantities of the element phosphorus. A good grade for domestic use contains from 12 to 13 per cent of phosphorus. This grade seems to have been adopted for domestic use, and the higher grades used for export because of the heavier transportation charges. The phosphate should be finely ground. The experience in Europe with slag phosphate has caused a general requirement that the grinding be so fine that 90 per cent of the material will pass through a sieve having one hun-

dred meshes to the linear inch. The fine grinding permits the material to be better distributed throughout the soil, and increases the rapidity with which the phosphorus is made available. There is much low grade phosphate in the mining regions, and this is being hawked about the country by irresponsible men who get any price they can for low grade and coarsely ground stuff.

Avoid any agent or salesman who tries to sell some particular brand of phosphate that is represented to contain phosphorus in a soluble or available form, or in which the phosphorus is contained in some peculiar chemical combination, the terms of which neither you nor he has any definite understanding. Such "fancy" material is usually sold at an increased price. Set the dogs on such agents. The only basis for you to consider is the phosphorus content and the fineness of grinding.

It is best to order direct from a reputable miner, with the definite understanding that the material is to contain from 12 to 13 per cent of phosphorus, and that it will be ground fine enough that 90 per cent will pass through a 100-mesh sieve. Have it clearly understood that settlement will be made on the basis of the guarantee as determined by a reliable chemist. When the car is unloaded, take a handful or more from each wagon load, and mix it thoroughly, and from this mixture take a sample to be sent to a good commercial chemist. If the phosphate is in bulk some idea of its fineness can be obtained from the weight of a full wagon box, as the finer it is ground the more bulky it becomes. When coarsely ground, or so that 60 per cent will pass through a 100-mesh sieve, a common wagon box will hold about two tons. When ground fine enough for 90 per cent to pass through a 100-mesh sieve, the same wagon box will hold but about 2,800 to 3,000 pounds.

How Much Phosphate to Apply.

Just how much phosphate to apply for the greatest profit has not been determined. Experience on Bois d' Arc farm shows a profit in applying 1,000 pounds per acre once in four years; and it also shows a profit in applying four to five tons at one time. If the other factors are sufficient to produce 100-bushel crops, it would be profitable to apply phosphate enough to balance the other factors. If we assume, as is usually considered, that the equivalent of one per cent of the phosphorus in the plowed soil can be used by one crop; then since it requires 23 pounds of phosphorus to grow 100 bushels

of corn, five tons of $12\frac{1}{2}$ per cent phosphate will give a total amount of phosphorus that is not likely to limit the crop below the 100 bushel mark. On land where the other factors, or any of them, that enter into crop production are low, such heavy applications of phosphate would not prove so profitable as smaller applications.

Experience has shown that the application of 1,000 pounds of phosphate once in a four-year rotation is highly profitable. This amount supplies sufficient phosphorus for a good growth of clover and causes a good increase in grain crops. It is adding phosphorus faster than it is removed in ordinary crops, and proves a good application to adopt in a permanent system. One ton per acre once in four years has more efficiency, and builds up the phosphorus content faster, and this amount is now the usual treatment on Bois d' Arc farm.

How and When to Apply.

No machine not made for the purpose will spread phosphate satisfactorily. As good a machine as any, is the one described in Circular 110 of the Illinois Experiment station, or the similar one described in the *Prairie Farmer* of Sept. 1, 1911. Even these machines require some experience to operate so as to spread the desired amount evenly. It is easier work and more economical to handle the phosphate in bulk, though in bags it may be handled somewhat faster. It is cheaper to spread as hauled from the car, and shifting wagons at the field requires but one extra wagon. An 8-foot machine can spread from 16 to 20 acres in a day. As spreading and hauling are the principal features in applying the phosphate, it can be more easily done during late summer or early fall when the roads are most likely to be good and the field solid. So far as the phosphate is concerned, it can be applied any time of the year without injury or loss except from erosion, when the soil itself washes away. As vegetable matter is to be depended upon to make the phosphorus available, the phosphate should be spread in close connection with the manure, clover or other legume crop that is to be plowed under. If it is intended to use phosphate principally for the coming legume crop, it should be spread and plowed under. Plant roots do not feed at the top of the ground, and phosphate applied as a top dressing or merely harrowed or disked in will produce little or no effect. A thorough disking to incorporate it with the surface soil before plowing will be a great advantage. Phosphate used for this purpose of aiding the legume crop is usually profitable, and frequently is the means of getting a stand of clover when otherwise there would have been a failure.

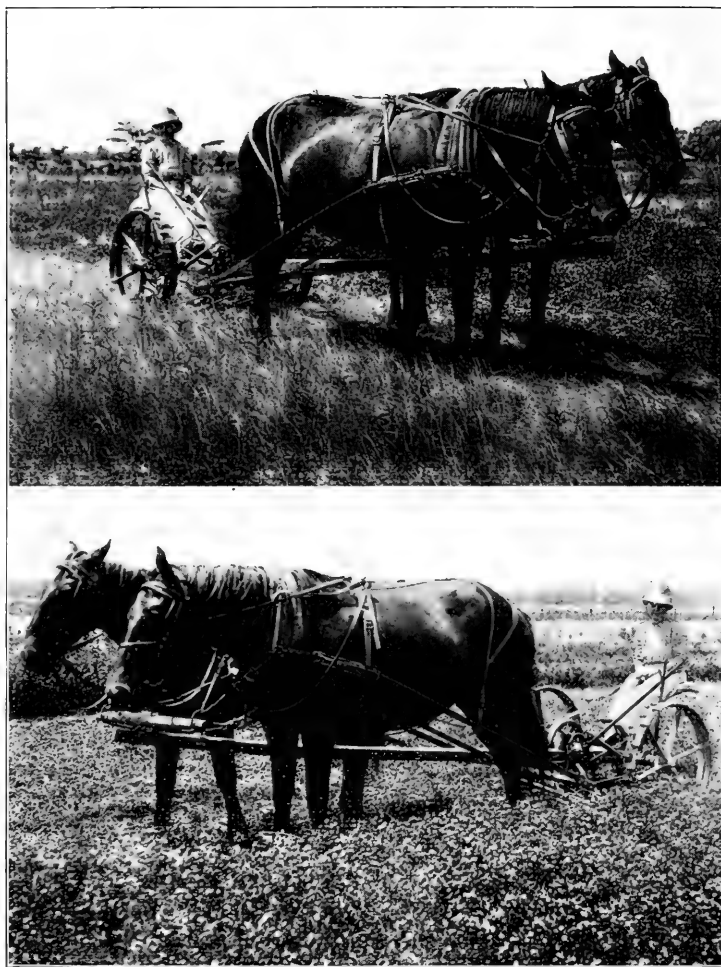


FIG. 7—VIEWS ON DR. HOPKINS' FARM IN SOUTHERN ILLINOIS.

1. NO TREATMENT AND NO CLOVER.
2. GROWTH OF CLOVER AS THE RESULT OF LIMESTONE TREATMENT

LIMESTONE.

The principal function of limestone is to correct soil acidity. The necessity of correcting an acid condition and of maintaining a sweet soil, is because the legume bacteria do not thrive in an acid medium, and without bacteria the legumes cannot secure nitrogen from the air. The use of limestone is a preliminary step to the growing legumes on acid soils. The first step in systematic soil treatment is to determine whether the soil is acid, and the amount of limestone necessary for its correction. To determine whether the soil is acid is a simple proposition. Get a nickel's worth of blue litmus paper at any drug store; make a ball of the soil, supplying moisture if necessary, though care must be taken that the water used is not acid, and that the soil is not handled with sweaty hands; crack open the ball and insert a small strip of the litmus paper, allowing a protruding end, and then close the ball. If the soil contains acid the blue color of the paper will be changed to red, and the time required to change color is an indication of the amount of acid present. If it does not change for several hours not much acid is present. It is very important that the subsoil also be tested for acidity, and if both soil and subsoil are acid then at least two tons per acre of limestone should be applied every four years.

Burned Lime.

In many of the older states large quantities of burned lime are applied to the soil. Burned lime, when fresh, is caustic, and has an effect of burning out the organic matter in the soil, just as it burns the flesh of the body. The use of burned lime has no place in a permanent system of agriculture.

Fresh burned lime does have the power to correct soil acidity; but not till it has lost its caustic properties by again being converted into carbonates through natural processes, will it supply calcium, and become desirable for use on the land. The usual deposits of limestone are composed principally of either calcium carbonate or a mixture of calcium carbonate and magnesium carbonate, called dolomitic limestone. There is little choice, if any, between these different forms. The dolomite is as good if not better than the high calcium limestone.

Losses of Limestone.

There is a constant loss of limestone from the soil through drainage waters, and to a less extent through the crops grown.

The information from the Rothamsted experiment fields, indicates a loss of about 800 pounds per acre annually. The writer has observed the gradual loss of limestone and lime concretions from the surface soil during thirty years, till now there is but little left on the surface of the higher land, though an abundance in the subsoil. This means that on the prairie corn belt soil we are practically face to face with the limestone problem.

How Much Limestone?

The amount of the initial application of limestone will depend largely on the amount of acid in the soil and subsoil. On highly acid soils the initial application may well be five tons per acre. On soils slightly acid, or where there are traces of a natural supply of limestone, the basis for computing the amount to be used is that of future losses. In either case it is worth while to apply enough to last for several years. It will require about two tons applied once in four years to insure a sweet soil.

On highly acid soils, where effects from limestone are desired immediately, the finely ground will prove the most efficient, but when applied as a future prevention of acidity, the coarser ground will prove more satisfactory, as it costs less and the future loss will be less. Some mills have a by-product in their regular grinding, that is removed by a quarter-inch mesh sieve. This material contains some that is very fine as well as the coarse, and is a desirable product when large applications are made, for both immediate and future effects, and can usually be bought at a less price than when ground fine specially for soils.

How to Apply Limestone.

When small amounts of limestone are to be spread, the machines referred to for spreading phosphate can be used with satisfaction. For spreading larger amounts, a slow geared manure spreader gives better satisfaction. An old binder canvas, or similar material, can be tacked on the platform, and the oiled bearings should be protected from the dust as much as possible.

Other Limestone Effects.

Another effect of limestone when used in large quantities is its peculiar power of flocculating clay particles, causing a granular condition, and thereby improving the physical con-

dition of the soil. The effects are similar to the action of large amounts of humus, and are noticeable from the ease with which such soil can be pulverized. In very heavy soils, where there is considerable clay, this action is followed by a deeper zone of aeration and bacterial action. A noticeable instance of such action has been observed in a garden spot at the home of Mr. H. A. McKeene, in Springfield, Ill., where the garden had been covered with subsoil from a cellar excavation, on top of which a quantity of limestone was applied. On Bois d' Arc farm quarter-inch ground limestone was applied at the rate of 20 tons per acre, to one half of a depression in the surface or old pond, where the soil contained considerable clay, and was quite impervious to water. The action of the limestone here has been apparent in increasing the porosity, and rending the soil more easily pulverized. An examination shows that the pervious layer of soil is deeper on the treated than on the untreated parts. This physical condition was probably reflected in the crop, as the corn yield that followed was 84 bushels on the untreated, and 112 bushels per acre, on the treated. For the oats that followed the corn, the treated ground was probably too loose, as they went down so badly none were secured. Both the stand and growth of clover that followed the oats seem to be benefited by the treatment.

Several carloads of limestone have been used on Bois d' Arc farm, that have been applied at the rate of about three tons per acre. But as the soil is not much acid, no great gains have come from its use, though there have been reasonable returns on the investment. The use of limestone will be continued, however, to prevent soil acidity.

PERMANENT FERTILITY IN A NUTSHELL.

To create and maintain a high fertility requires only three things: to grow and add to the soil enough legume crops to supply sufficient nitrogen, active organic matter and humus; to add more phosphorus than is removed in the crops; and to supply calcium and prevent soil acidity by the use of limestone. Nothing else need ever be done for permanent high productive power on normal soils.

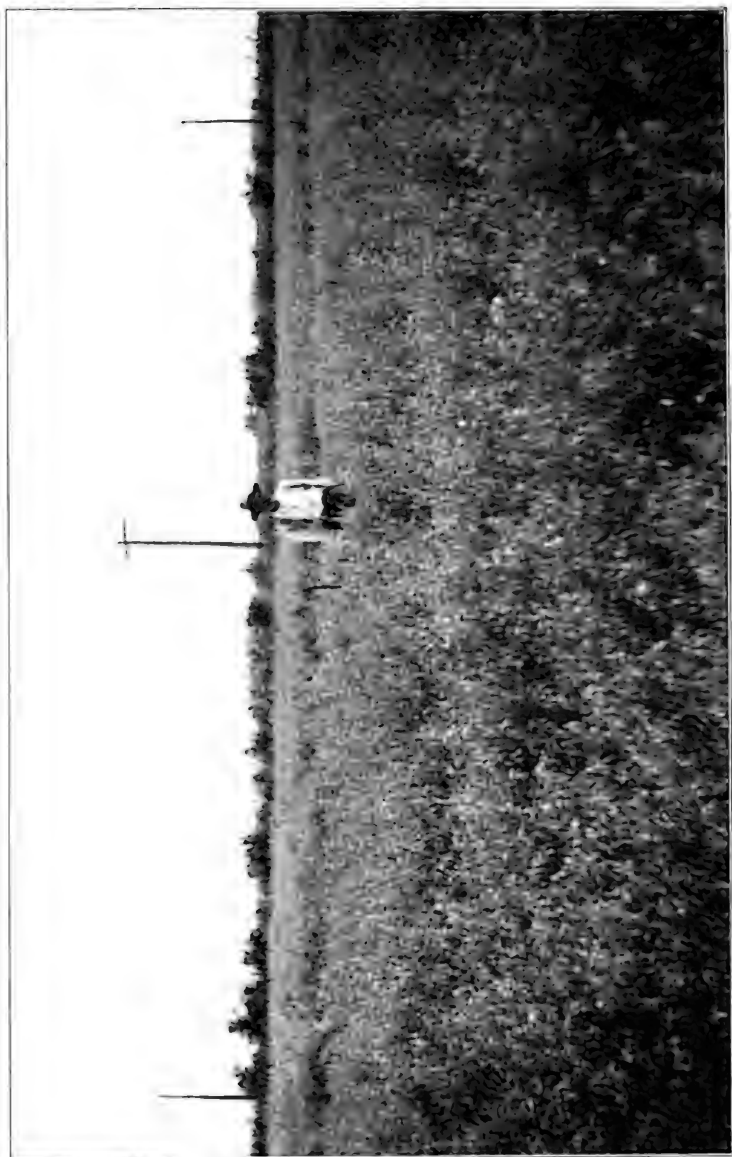


FIG. 8—OATS ON UNTREATED SOIL. FOUR YEAR ROTATION FOR 24 YEARS YIELD, $5\frac{1}{2}$ BU. PER ACRE.

WHAT DOES FERTILITY COST?

To apply phosphorus as fast as it is removed in crops, and to provide a reasonable amount for an increase in fertility, will require the application of about 1,000 pounds of phosphate once in a three or four-year rotation. At average points of shipment, this will cost about \$4 for each treatment, or approximately \$1 an acre per year. The cost of limestone, considering the average loss, will approximate 50 cents an acre per year. It will never be possible to avoid such expenditures under any permanent system. The cost of these materials may be somewhat modified in the future, and it is logical that limestone may decline at some points, through a greater development of the industry. It is quite possible that phosphate users have an opportunity now that may not be realized after a few more years. It is the man who gets in this game early, that will probably realize the greatest gain.

If \$1.50 an acre annually was levied on land as a tax with its present productive capacity, it would have a serious effect on many landowners, and would spell disaster to some. But this expenditure should be considered as an investment. It is an investment that gives good direct returns, and more than this, it protects the value of the investment heretofore made in the land itself. Nothing but soil treatment will prevent a decline in the productive power of the land, sooner or later. If large investments of this kind are not possible, a start can be made with a small investment. If the increase in crops the first year, or the first rotation, returns a value of \$2 or \$5, or \$10, for each dollar invested, let these returns be established into a trust fund, to be used only for further soil improvement. Do as the stock jobbers advise—pyramid the operations. If this trust fund is kept inviolate and all returns from previous soil treatments be added to it, soil building in a permanent way will not be burdensome, but will give new interest and zeal to life. And do not violate this trust fund in a few years to buy an automobile or another farm.

EXPERIENCE ON BOIS d' ARC FARM.

Bois d' Arc farm is composed of nearly 500 acres of the corn belt dark prairie land, better described as the brown silt loam of the early Wisconsin glaciation. A half-section is divided into 80-acre fields, which have been cropped in a four-year rotation for about 30 years. The remainder of the farm is divided into smaller fields, on which pasture is in-



FIG. 9—THIS FIELD WAS IN FOUR YEAR ROTATION 24 YEARS. HAD TWO 1,000 POUND APPLICATIONS OF ROCK PHOSPHATE. YIELD, 78 BU. PER ACRE.

cluded in a longer rotation. The half-section is mostly gently rolling to flat, and all surplus water is carried away in tile systems. On part of the remainder is a moraine formation of about 80 acres, having a rise of 30 to 40 feet. From 30 to 40 milk cows have been kept for many years, and about 20 head of work horses and colts. Manure is hauled to the field and spread while fresh when it is possible to do so. One 80-acre field has been kept as a check against the value of manure, and this field has never had any manure or pasture. On this half-section clover has been grown every fourth year, with but one or two exceptions. After several rotations had passed it was realized that clover was losing its efficiency in the production of grain crops. Shortly after the Illinois Experiment station discovered that phosphorus was needed on some of the Illinois soils, applications were made to small plots on these fields in order to ask the soil what it did want. Applications were made of bone meal, rock phosphate, dried blood, potassium salts, and limestone. Several cars of manure from the stockyards were used in one field about the same time.

Where the manure was used there was an increase in the yield of corn of 10 bushels per acre. Where the phosphate was used, either in bone meal or rock, the increase was 17 bushels of corn. Where the blood or limestone was applied, the increase was less than one bushel per acre. Potassium produced no apparent effect. It was concluded that, as nitrogen in the blood gave no increase, it was likely that the nitrogen in the manure had given no increase; and as there seemed to be enough decomposition going on to liberate phosphorus from raw phosphate, it was also likely that the organic matter of the manure had caused no increase. This indicated that the increase from the manure was caused by the phosphorus it had supplied.

The cost of the manure was 55 cents per ton, making the cost of the application \$5.50 per acre, with practically three-fourths of it used, leaving enough in the soil to produce only about 35 bushels more corn. The phosphate cost \$4 for the application, and only about 10 per cent of its value had been used the first year, leaving enough in the soil to produce nearly 500 bushels more corn.

After similar trials, and the analysis of samples of soil by a son in college as a part of his student work, a systematic treatment with phosphate was commenced. The plan established was to apply 1,000 pounds of ground raw rock phosphate per acre once for each four-year rotation; the application to be

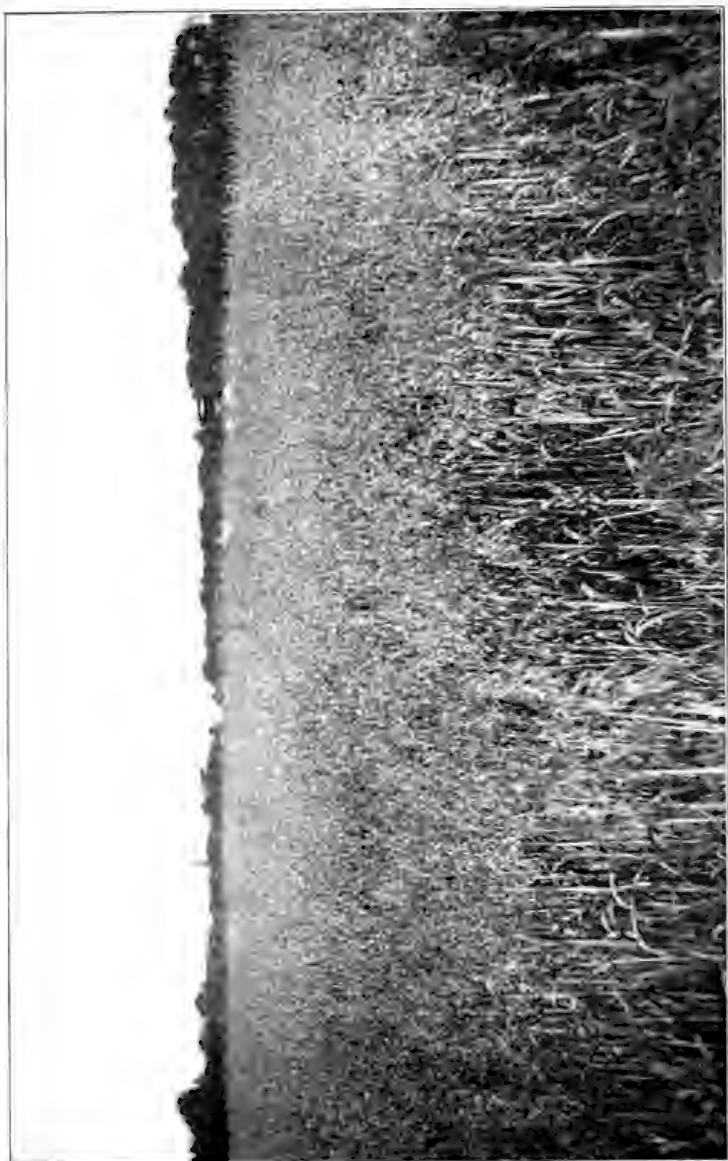


FIG. 10—HEAVY TREATMENT, FOUR TONS ROCK PHOSPHATE PER ACRE.
FOUR-YEAR ROTATION 24 YEARS. YIELD, 89 BU. PER ACRE.

made to the clover field before it was plowed in the fall. The trust fund has justified better investments, so that some extra treatments have been made, and the plan has been changed to apply one ton each rotation instead of one-half ton. Check strips were left in most of the fields, to which no phosphate has been applied, but in every other respect are treated the same. These were left in order to get a measure on the value of the treatment. In addition to the regular treatment, strips of heavy treatment have been given in most of the fields, and some small fields covered with the heavy treatment except the checks. On these heavy treated portions enough phosphate is applied to make five tons as a total of all that has been applied, estimating what has been removed in the crops. The rotations have now been twice around since the plan of treatment was adopted, so that every field has had at least two applications, with the minimum of one ton per acre, though some have had more than this.

Some Results.

The average increase of crop yields for the first treatment was 15 bushels of corn per acre; 20 bushels of oats; one ton of clover hay, and 15 bushels of wheat. As the cost of treatment averaged \$1 an acre per year, there was realized either 15 bushels of corn, or 20 bushels of oats, or one ton of clover, or 15 bushels of wheat for each dollar invested. There was also left in the soil about one-half the value of the treatment for the use of future crops.

No part of these fields has been kept as a check to measure the effect of growing clover in rotation, and to get some estimate of this value, yields are taken from some of the adjoining land, which has been farmed in a two-year rotation of corn and oats without clover, for many years, and in which the soil formation, natural drainage, etc., are strictly comparable. The following table gives comparative yields for the first five year period after treatment was commenced, of the three systems: a two-year rotation; a four-year rotation, with clover; and a four-year rotation with clover and phosphate:

	Corn, Bushels.	Oats, Bushels.	Clover, Tons.
Two-year rotation, corn and oats.....	34	32	..
Four-year rotation, with clover.....	54	47	1½
Four-year rotation, with clover and phosphate...	70	70	2½

This shows a gain of 20 bushels of corn per acre each year from the use of clover in the rotation, and a further increase of 16 bushels for the phosphate over the clover increase. In the oat crops the gain for clover alone was 15 bushels, with

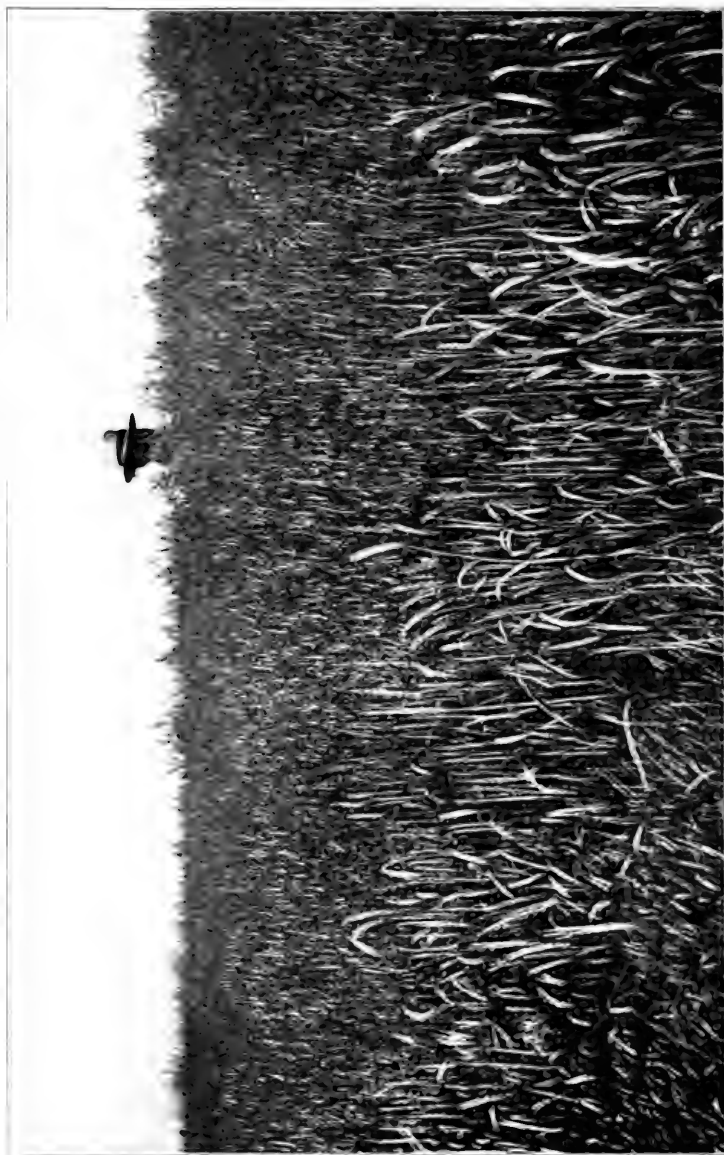


FIG. 11—ALFALFA 7 YEARS, CORN 2 YEARS, ONE TON ROCK PHOSPHATE. YIELD, $88\frac{1}{2}$ BU. PER ACRE.

a further increase for phosphate of 23 bushels. The increase in the clover comes largely from the better stand and growth on the thinner parts of the fields, where there is an increasing difficulty in getting a stand on the untreated soil.

The following table shows the relative yields from different soil treatments the first year after heavy treatment:

	Corn, Bushels.	Oats, Bushels.
Two-year rotation	25	31
Four-year rotation, with clover.....	67	55
Four-year rotation, with clover and regular phosphate treatment	84	78
Four-year rotation, with clover, four tons phosphate.....	92	89

The comparison here was modified somewhat because of a destructive hail storm that came before the maturity of the corn. The figures show to some extent the influence of the treatment on the earlier development and maturity of the crop. Because of the treatment, the corn was further advanced in its growth, and contained more substance within the stalk with which to complete the crop, while the corn in the two-year rotation was abnormally low in the yield because of the injury from the hail.

The value of phosphate treatments in the season of 1911 was modified to some extent by the extremely dry conditions. In small grains, the increased yields from phosphate applications were up to the average, if not above. A field of oats where one ton of phosphate has been applied yielded 80 bushels per acre, while the average yield of untreated land was about 40 bushels. In wheat, the increase was from 35 bushels, the untreated yield, to 50 bushels where the treatment had been one ton of phosphate, and 52 1-3 bushels where the treatment had been 1½ tons. In corn the average increase was 10 bushels per acre, which is less than the average. This smaller increase was no doubt due to the inability of the corn roots to feed as freely as usual in that part of the soil which contained the applied phosphate, because of the continued dry conditions. More than usual of the surface soil was too dry for root development, and the root zone was considerably narrowed in the zone of treatment.

Cases have been reported where phosphate was applied in the spring to fall plowed fields, and worked in with a disk when preparing the ground for planting corn. This method has usually resulted in disappointing returns. The disk could not incorporate the phosphate with more than 2 or 3 inches of the surface soil; and later, this same 2 or 3 inches was used to make a dust mulch, thereby preventing

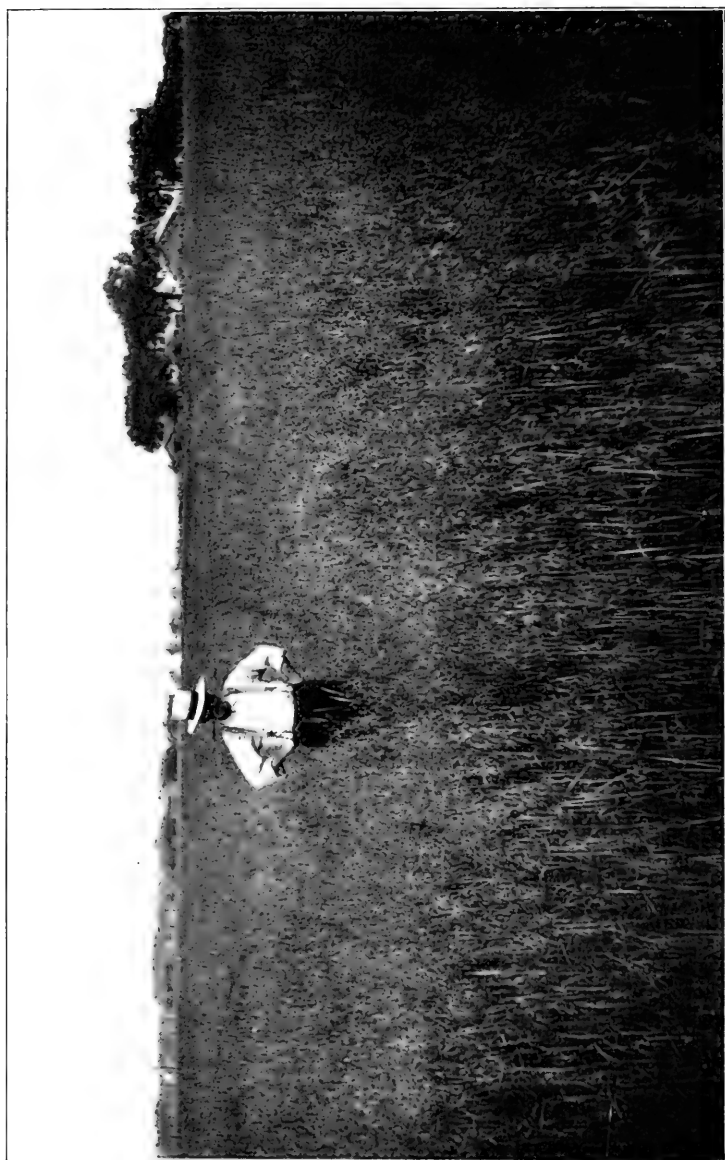


FIG 12— FIELD JUST ACROSS ROAD. COMMON TWO YEAR ROTATION. NO TREATMENT.
YIELD, 31 BU. PER ACRE.

any root development that could come into contact with the phosphate. If the mulch was occasionally saturated by rain there might have been some benefit from the treatment, but when the mulch was not wet through during the growing season no benefit could possibly be realized. It should be well understood that the phosphate must be where the roots develop and feed; otherwise there can be no benefit from the application, at least for that year.

Effect of Soil Treatment on Quality of Grain.

Another value from the treatment is its effect on the quality of grains. This probably comes under the theory of a balanced ration for plants the same as for animals, as this same effect has been observed from a nitrogen treatment when nitrogen was quite deficient. One factor in quality is maturity. Much of the complaint from commercial interests of the poor quality of grain is due to its lack of maturity. This can not be altogether remedied by growing smaller or earlier varieties of corn, as even the earlier varieties of field corn and the small varieties of pop corn contain many ears that are not fully matured. There is a difference between mature grain and grain that merely stops in its growth at the proper season, and then dries out. Maturity is a completion of the process of growth, and not simply a cessation of growth, and the completed growth or full maturity can not take place unless there is a sufficient supply of every element of plant food. When crops do not fully mature the grain is light in weight and chaffy, or it may contain an excessive amount of moisture, much of which might have been utilized if properly fed, and a fully ripened condition reached.

Some comparisons have been made between treated and untreated portions of fields as to the difference in the maturity of the crops. One test showed 35 per cent of the corn on untreated ground was well matured and solid, while the treated part of the same field, with the same variety of corn and other conditions comparable, the percentage of equally matured and solid corn was 84. In the season of 1911, when there was no frost till late in October, several weeks after corn fields were ripe; a year when maturity was not interrupted by weather conditions, corn on untreated ground showed 60 per cent solid ears, and on the treated there was 85 per cent of solid corn. The effect of treatment on oats is usually noticeable. In one case, oats weighed 26 pounds per bushel on untreated land, and 35 pounds on treated land, and there is usually a difference in weight. There is also

a marked difference in the appearance of wheat from the treated and untreated ground, and the treated wheat is superior for milling purposes.

WHAT IS LAND WORTH?

There have always been believers that land was too high in price. The original government price of \$1.25 an acre was thought by the pessimist to be too high. When it sold for \$10 an acre he thought the price was too high; when it reached \$50 he thought it was too high; and when it reached \$100 he knew that was too high; but since that he has held his breath.

What is land worth? It is worth any value on which it will bring reasonable returns. Land with a productive capacity of 20 bushels of corn or oats per acre is not worth much to the owner. It is worth such a crop in labor to grow the crop, and if the land owner gets anything from it, it is at the expense of the land worker's labor. If the land owner and land worker should be the same person, whatever he receives is as a land worker and not as a land owner. If the land will produce 50-bushel crops, there is enough for a division; enough for reasonable compensation for the labor of the land worker, and enough for small returns for the land owner, on the usual present valuation.

If the land can be made to produce 80-bushel crops, there will be enough for good compensation for the labor of growing the crop, and enough left for the land owner as returns on a valuation that is more than twice as much as the present selling price of good land.

What is land worth that for seven years produced 5 tons alfalfa per acre, each year the crop being worth as feed for growing stock as much as 200 bushels of corn; that the next year produced 20 tons of silage per acre; the next year produced 115 bushels of corn per acre; the next year produced 88½ bushels of oats per acre; the next year produced 52 bushels of wheat per acre?

Whether land values in the future will be increased or decreased will depend on what the landowner may have done for the land; whether he has kept up its productive powers, or whether he has permitted the usual decline in fertility.

RELATION OF LANDLORD AND TENANT.

Baron von Liebig said: "It is not the land itself that constitutes the farmers' wealth, but it is in the constituents of the soil, which serve for the nutrition of plants, that this

wealth truly consists." A farm, then, is similar to a retail store—its value is mostly in the stock of goods. The land renter is like the clerk in the store, and as it is the clerk's business to get all that he can out of the stock of goods, so it is the renters' legitimate business to get all he can out of the land. If the clerk does not know his business, then comes a new clerk; and if the tenant does not know his business, or enough to get good crops, then there is generally a new tenant. It is the storekeeper's business to keep up the stock of goods, and in a well-balanced supply; so it is the land owner's business to keep up a well balanced supply of the constituents of the soil. If the store keeper fails to keep up the stock of goods, the time comes when he has no store; if the land owner fails to keep up the land, the time comes when he has no farm of much value.

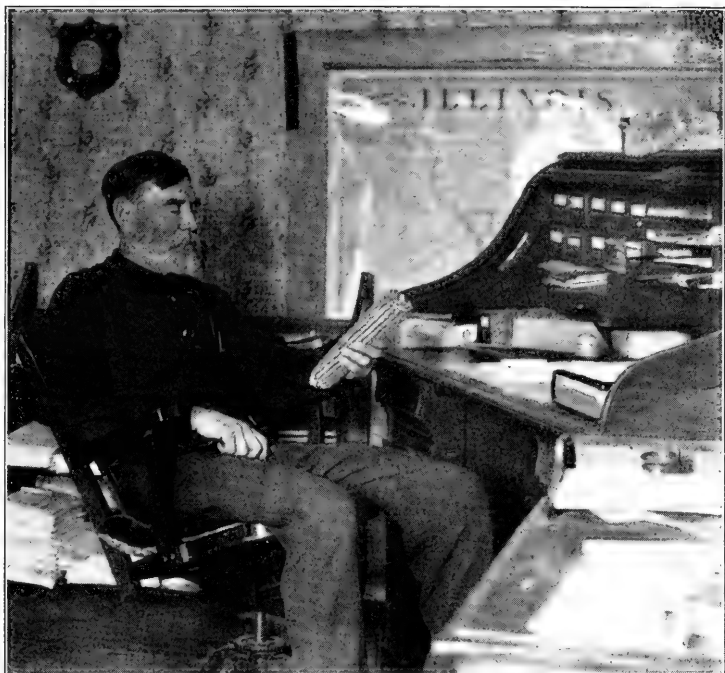


FIG. 13—IT PAYS TO RAISE POUND EARS.



FIG. 14—THIS WHEAT FIELD YIELDED $52\frac{1}{2}$ BU. PER ACRE IN 1911.

Part III

THE ART OF AGRICULTURE

Any discussion of the methods used in the art of agriculture is made difficult by the large number of combinations that can be made when the weather, the climate, the soil, the crops, and the farmer himself are factors, and nothing said here is intended to be absolutely "fool-proof." It is intended to offer a few suggestions that may call the attention of the busy farmer to some of those things in every day affairs, which in his haste and hurry, he may have overlooked, and which should be considered only when in harmony with common and normal combinations of the various factors.

TILE DRAINAGE.

On the so-called level land and on the gently undulating land, having a reasonably pervious subsoil, the first essential for good crop production is a good system of tile drainage. Definite information as to what would make an adequate system for a given piece of land, would be impossible, without knowing the character of the subsoil, the amount of grade that could be secured, and the contour. The size of the main strings will depend on the amount of grade that can be given, the amount of land to be drained in them, and the "lay of the land"—the size of the depressions where the water gathers in ponds, and the extent of the watershed into these ponds. Capacity should be given the main system so as to remove all standing water within 12 to 24 hours after a "flood." The sub-mains that follow the natural depressions other than the mains, should be large enough to carry all the water furnished by the lateral strings to the main string within twelve hours. The size will depend on the grade and the area drained by the sub-mains and its laterals, and usually nothing smaller than six inch tile is used for this purpose, and generally eight inch tile are used. The lateral strings should run parallel with each other, and branch off from the sub-mains.

The distance apart between laterals will be modified by the character of the subsoil, but consideration should be given to the changing tendency of the subsoil to drain less

readily. Land that many years ago would drain fairly well with the laterals 150 feet apart, will not now drain so well with laterals 100 feet apart. As the humus becomes more and more depleted the distance required between lateral strings will be affected. Even where the humus has been fairly well maintained a distance of four or five rods between laterals has been found to be desirable. The size of the tile for the lateral strings is not controlled by the amount of water to be carried by them, usually, but by the "crack space"—the cracks between tile—to let water enter, and by the ability to overcome the accumulations of sediment. Five inch tile are most desirable for laterals, though four-inch are more largely used, and prove satisfactory for at least 40 years, as long as experience goes on Bois d' Arc farm. A system of this kind, where both the low and high ground is included, will provide thorough drainage, and will cost not far from \$20 an acre.

While tile drains laid deep in the ground will drain a greater distance on each side, and this plan is frequently recommended by drainage engineers, it is found that the soil near tile not laid so deep is as well drained, stands drouth better, and keeps in better physical condition. From 30 to 36 inches in depth has given the best satisfaction, one year with another, though it requires that there be less distance between strings, and consequently more tile.

Some advantages of thorough drainage are: a deeper porosity of the soil, thereby extending more deeply the zone of liberation of plant food; an encouragement of the bacterial actions in the soil; more efficient results in all soil operations, as plowing, disking and cultivating; the ability to work such a soil at the right season, without being delayed by wet places; a lack of germination of weed seeds; and economy of labor.

Where water stands on a crop for any length of time, there seems to be a deadening of the soil activities, and a standstill in the growth of the crop for some time thereafter, which is probably caused by the destruction of the soil bacteria, and the washing away of available plant food, certainly of nitrates, so that the crop practically stands still in its growth until more plant food becomes liberated. Such a loss in the growth of a crop may mean the difference between a poor crop and a good one.

Having to wait a few days longer after a heavy rain for some wet spot in the field to dry up, may mean not only a loss of time with the farm help, but it means several days' start for the weeds or a loss of several days' growth of the

crop. The seeds of some of the most common weeds require excessive moisture conditions for their germination. Drainage is one of the greatest aids in overcoming weed injuries, because of this lack of germination of the seeds, and because of the greater ease with which they are destroyed in the process of cultivation.

It is only on well drained fields that we can depend on being able to do the early disking that is so efficient in preventing certain insect injuries.

PLOWING.

No definite rules can be established as to the depth which ground should be plowed, because it is affected by so many different conditions. Probably the most valuable result of plowing is to give aeration, which increases the bio-chemical actions in the soil. A plowed and well pulverized soil gives better opportunities for these activities, that are essential.

Another effect from plowing comes from the fact that a loose, porous soil has a greater moisture holding capacity. These facts are the foundation of the arguments of the advocates of deep and subsoil plowing. Another fact that must be taken into consideration in the same connection, is that the root development does not take place so well in a soil that is too porous and too loose. While the arguments for deep and subsoil plowing are attractive, the results are frequently disappointing. The conditions or combination of factors that exist, may, however, greatly modify the results.

Another purpose of plowing is to get vegetable matter into the soil, and again the depth to plow is modified by the conditions. The conditions most liable to modify the results from deep plowing are: the kind of season following, whether wet or dry; the amount of humus in the soil, and especially the humus in the subsoil; the character of the subsoil; and the methods of tillage that follow. On land where clover has been grown in rotation, and the subsurface and the subsoil kept reasonably porous and loose from clover roots; and where considerable vegetable matter is usually plowed under, the experience on Bois d' Arc farm has favored shallow plowing.

A number of years ago a subsoil plow was tried. A special plow was made with a subsoil attachment, which would merely lift and loosen from four to six inches below the turned furrow. With this plow the soil was loosened to a depth of twelve to fourteen inches. Twenty acres were also plowed with two plows. One plow turned a furrow from nine to ten inches deep, and the other plow, which had but a share and no mould-

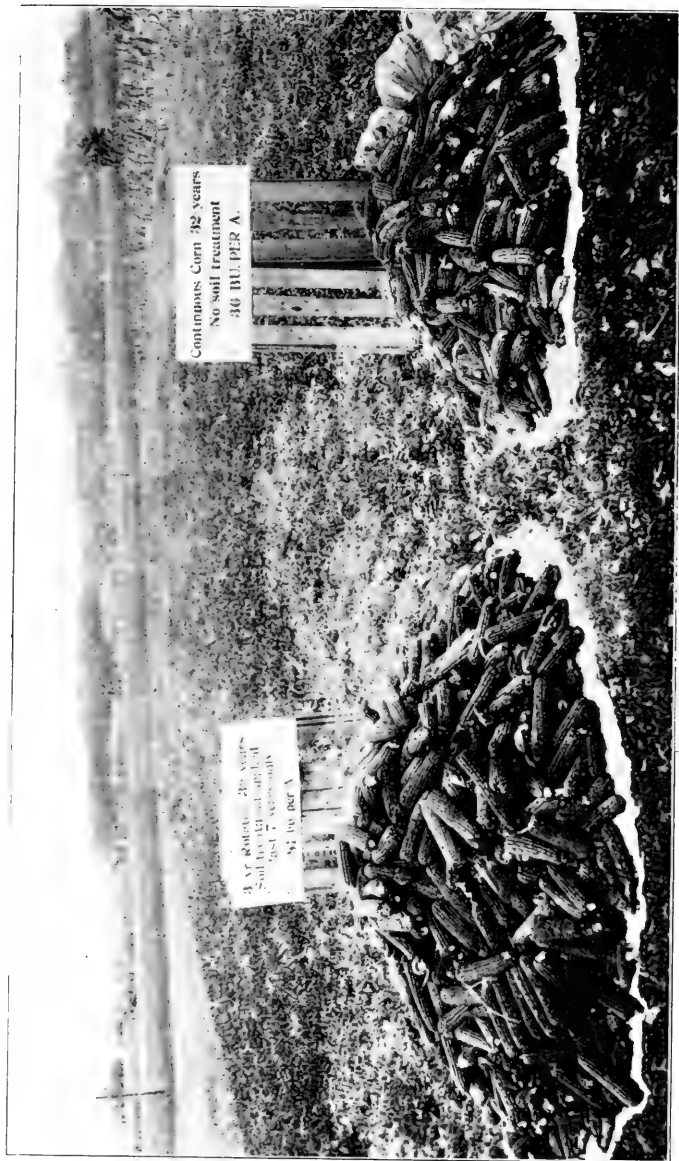


FIG. 15—RESULTS OF SOIL TREATMENT AT ILLINOIS EXPERIMENT STATION.

board, followed in the furrow and lifted another ten to twelve inches in depth. With these plows the soil was loosened to a depth of from 18 to 20 inches. The crop results from all this deep plowing was a disappointment, and it was several years before this land got back to its normal productiveness. Where no clover or deep rooting crop is grown, and there be more or less of a "plow pan" formed; and on some kinds of soil deep and subsoil plowing may be very desirable. It is well to be conservative, however, and not change a method of plowing except under a complete demonstration with comparable conditions.

The time of plowing is greatly modified by different conditions. Where the soil contains much clay, and is not easily pulverized when plowed in the spring, it is desirable to plow in the fall, and let the freezing weather do the pulverizing. Soils that run together again during the winter into a mass as compact as before plowing will give better results when plowed in the spring.

Early fall plowing, or plowing done in the late summer, is to be commended only under certain conditions. When the weather conditions are such that a growth of weeds or a volunteer grain growth may develop, this may utilize the plant food as it may become available, and through its decay, turn it over to the following crop. When no such growth is made during the time of fallow, much of the available plant food is carried away in the drainage waters. When plowing is done late in the fall the soil activities are at a minimum thereafter, and the loss of plant food is less during the winter. Another advantage of plowing late in the fall, is the effect on certain insects. Those insects which establish themselves for the winter above the plow line, are not likely to recover from the disturbance and exposure to the elements.

DISKING.

The disk is the best tool on the farm, and if farming had to be all done with one tool, that tool would be the disk. It is the best tool ever invented to compact and pulverize soils, and the main fault is that it is not used enough. There is a constant tendency from disking to form a "plow pan," which should occasionally be broken up by deep rooting crops or deeper plowing. In the hands of a careless man it is easy to form ridges in loose ground with a disk, but ground can be disked as often as desired and kept level, if the disking is always done in the same directions, and "splitting the middles"

each time. A man who can drive a disk straight is worth more wages than one who "runs amuck" in the field.

A disk on dry ground is valuable, but on wet ground is an abomination. A rusty disk is not much good where soils do not scour easily. A great aid in keeping disks and other tools bright is to have handy a small pail of common black lubricating oil and a paint brush.

CULTIVATION.

There are many different ideas and customs regarding methods of cultivation; and before one departs far from established customs it might be well to wait for positive demonstrations. An understanding of certain conditions in the growth of crops is essential in applying the best methods. In the growth of a grain crop there is an enlargement of the stalk, leaves and root systems until about the time the grain commences to form, after which the enlargement ceases and the growth is one of transference of plant food from the stalk and leaves to the forming grain, and the formation of the starchy portions of the grain. The ability to form the grain is dependent somewhat on the extent to which the stalk has been supercharged with the plant food, and at which time the demand on the soil for plant food has been practically completed. This indicates the importance of securing a strong growth of plants during the early stages of development; and this requires the largest possible root development. The best development of a root system will occur when the full zone of aerated soil is accessible to the roots, and the root system will be diminished when too much of the root zone is kept too dry and loose for root development. There is no question as to the conservation of moisture by a dust mulch, but when the mulch is to be made from that part of the soil that has received the most aeration, and consequently has the greatest amount of available plant food, it becomes a proposition of whether the surface is worth the most for the plant food in it, or to use as a mulch for the conservation of moisture. Opinions and practices differ greatly, but the results at the Illinois Experiment Station for 11 years, indicate that the surface soil has more value when used for the plant food, than when used as a mulch. Series of plots have been conducted for 11 years. On one series, the surface has been scraped only sufficiently to prevent the growth of weeds, and another series has been given ordinarily thorough cultivation. The total yield for 11 years on the scraped plots has been slightly larger than on the cultivated plots for the same time.

Neither does it seem that deep early and shallow late cultivation is the best, as the time when the crop needs most what is in the soil, is in its early stages of growth, and anything that tends to check or divert the root system does not meet compensation later in the season.

Though results may be modified by conditions, experience indicates that on ordinary land, the best results will be obtained when only that part of the surface is used as a mulch which would not be otherwise used by the roots because of natural conditions.

CORN.

After provision has been made for feeding a good crop, then the details of the art of agriculture need skillful and intelligent application. One of the most essential things is a proper stand of corn. What constitutes a good stand of corn? It depends. Corn should be planted with reference to the habits it has formed. If corn has the habit of small stalks and a large number of small ears, it should be planted with reference to that habit. If it is some variety of sweet corn that has the habit of heavy stooling, there may be a different standard for a stand. If it is highly bred field corn, the amount required for a stand should be adjusted to those habits which have been more or less fixed by the breeder.

Breeding for Productiveness.

By selection certain habits can be developed in corn, which can be used to advantage in increasing yields. There are now many corn breeders who are growing corn with systematic reference to fixing certain characteristics or habits. Some are using the ear-row method, where a large number of ears are planted, each ear being given a row, and a few rows selected each year that meet more nearly the conditions required by the standard established. Where this selection is based on a certain type of ear, that type of ear is likely to be approximated, and other characteristics liable to be lost. When the basis of selection is only that of productiveness, uniformity of type is lost, but productiveness is increased. That there has been an increase in general field yields from selection for productiveness, there is no doubt. The difference in field yields when one part was planted with the mixed seed from high yielding rows, and another part with seed from the low yielding rows, has usually varied from one to five bushels per acre, in favor of the high yielding seed. What total increase may be accomplished from breeding for productiveness is impossible to estimate, as there is no satisfactory basis for long comparisons.

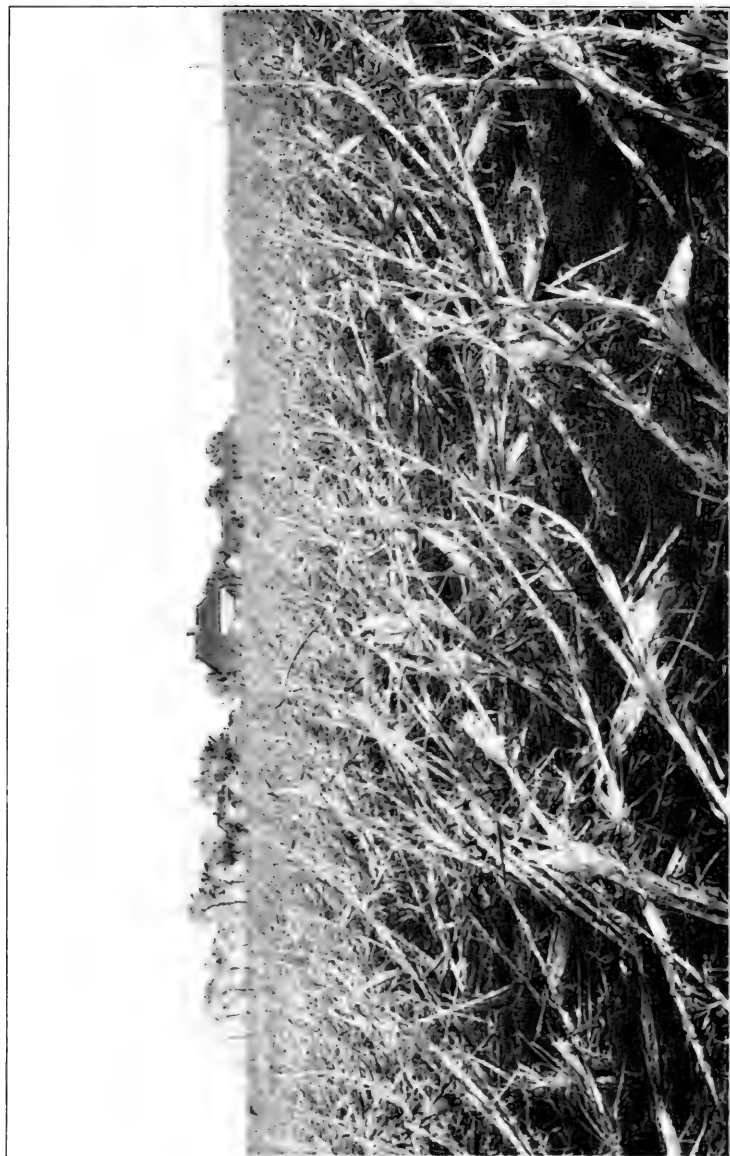


FIG 16—THIS CORN ON TREATED LAND YIELDED 70 BU. PER ACRE IN 1910, AFTER BEING KNOCKED DOWN BY HAIL STORM. CORN ON ADJOINING UNTREATED FIELD YIELDED 25 BU. PER ACRE.

Most of the corn breeders in the central corn belt are breeding corn for productiveness, and the standard adopted and the results secured indicate that planting corn with reference to the production of the largest number of one-pound ears is the most satisfactory. In the northern part of the corn belt a different standard may be required. Most of the corn grown in the central belt has been bred with reference to the production of pound ears, and for best results it should be planted with reference to this fact. Corn should be grown with reference to the latitude to which it has been adjusted, and there should never be any violent changes made in the latitude.

One-pound ears are none too large as a standard for Central Illinois, and on well treated soil larger ears are safely matured. One pound of corn for every hill, in ordinary planting, makes over 50 bushels per acre, and two one-pound ears per hill makes over one hundred bushels per acre—a standard high enough for the best soil. It might be noted here that in the dry year of 1911, an acre of corn planted with just one kernel to the hill yielded 51 bushels, while the adjoining corn planted two kernels to the hill yielded 57 bushels.

Testing and Grading.

If but two kernels per hill are to be planted it must be with a strong assurance that they will grow. To test every ear for germination is a good plan, but do not plant every ear because it has germinated. Shell every ear by itself; give it close examination, and unless it shows that bright lustre of high life; or if it shows a poorly developed heart, throw it out. Do not plant any ear that shows space at the cob.

Give the corn planter a chance—grade the corn. If there is much variation in size of kernels, grade the ears before shelling, and look over the ears before shelling and throw out the bad kernels with a knife. Take off the tip kernels down to the normal grains. It is best to remove the butt kernels, also, but it is not so material, as the grader will take out the worst. Grade with any good grader, feeding it slowly enough to do good work. It will not spoil the corn if it is graded more than once. Fit the plates of the planter to the corn, and give a test. Do not depend on a few drops in a drop test. Try a thousand drops, and do not stop until you approximate 90 per cent perfect in a long drop test. When you commence planting, again give the planter a chance. Drive steady, take a gait that the team can keep. Lengthen the tugs—it will help some to overcome the “horse motion” which gives an uneven

depth in the hills. Do not be in a hurry, take time to do it right. If the ground was well plowed and disked properly afterwards, the ground will be comparatively level, and every hill may be planted at proper depth. If it has been ridged when disking, or laid off in squares by disking both ways, or holes left in plowing, some hills may be planted so deep they will not grow, and other hills may be so shallow the corn can not germinate.

Getting Ahead of the Insects.

To maintain a stand of corn against insects requires that the ground be disked several times before planting time. If the ground is disked in the spring often enough to keep all weed growth down before it gets much above the surface, those insects which require fresh vegetable growth for their feed are practically all destroyed, either by starvation or from the disturbance and exposure. This method has proven very efficient against root aphids, cut worms, web worms and perhaps others. In 1911 a strip used as a check against frequent disking was damaged about one-half by web worms, while a count of 10,000 hills of corn in the field that had been disked four times at regular intervals showed not a single insect injury. This frequent disking may not be possible on land that is not thoroughly drained, or during a wet spring.

Feed the Squirrels and Birds.

To maintain a stand of corn against the enemies that live above ground, it is best to feed them. Boil some shelled corn and scatter on the surface of the field as soon as the corn is planted, especially along the edges and sides next to grass lands. A bushel will protect from 10 to 20 acres, and is much cheaper feed for birds, squirrels, mice, etc., than seed corn. As you do not want any of this scattered corn to grow, it is necessary to give it considerable heat to kill the germ. If this corn is mostly picked up or eaten before the planted corn is out of their reach it is necessary to scatter some more.

When the early disking has been done, and a good disk and smoothing harrow has been used immediately before the planter, it is advisable to keep out of the corn field after planting until the corn is large enough to do a good job of cultivating. It is under these conditions, unnecessary, and to some extent harmful, to run a weeder or harrow over corn when sprouting or after it is up. The weeder may kill some weeds, but there are enough left to require a good cultivation, and some plants may be injured in the process so as to cause freaks and malformations.

OATS.

While the soil is the most important factor in securing good oat yields, there are other factors that need attention. These are the quality of seed, the right amount of seed, and the even distribution of the seed.

From the breeder's standpoint ordinary oats are a badly mixed lot of strains and characteristics, and cannot be considered as purebred. It is probable that some varieties, at least, have within them an inferior strain, that develops as a small oat, with inferior growth and yield, and that this inferior strain can be, to some extent, removed by the fanning mill method, or a screening out of the small oats. It cannot be contended that oats can be bred into a pure strain through any fanning mill selection, nor can any variety be modified in its characteristics, except where such modification comes from the elimination of some quality accompanying size.

Increasing Yields by Grading.

The first year that Silvermine oats were graded over a sieve having about ten rectangular meshes per linear inch, the loss through the sieve was about 60 per cent. The next year, the loss was 50 per cent; the next year 40 per cent; then 30 per cent; since which the loss varies from 20 to 25 per cent. Before any grading of oats was done, a bushel contained about 800,000 kernels. After five years of grading a bushel of the same oats ungraded contained about 550,000 kernels, showing that there had been a gradual elimination of some of the small oats. As the number of oats in a bushel had been decreased, it was logical that more bushels of seed would be required for a proper seeding. Some tests were made by sowing different amounts of graded seed in comparison with the small rejected oats, with the following results:

	Small Oats.	Large Oats.	Large Oats.
Seed, bushels per acre.....	2½	2½	3½
Number of kernels per acre....	1,625,000	1,000,000	1,500,000
Yield per acre, bushels.....	35	65	80

The conclusion was drawn, and it has been confirmed by later experience, that on good land, the best seeding is about one and one-half million kernels of good graded oats per acre. This number may not be the best for all varieties and for other conditions, but it is well worth a farmer's time to grade well his seed oats and ascertain by count what amount of seed is best for his conditions. If there is no compensation from the decrease in the number of kernels per bushel from grading, by using more bushels for seed, the gain from grading

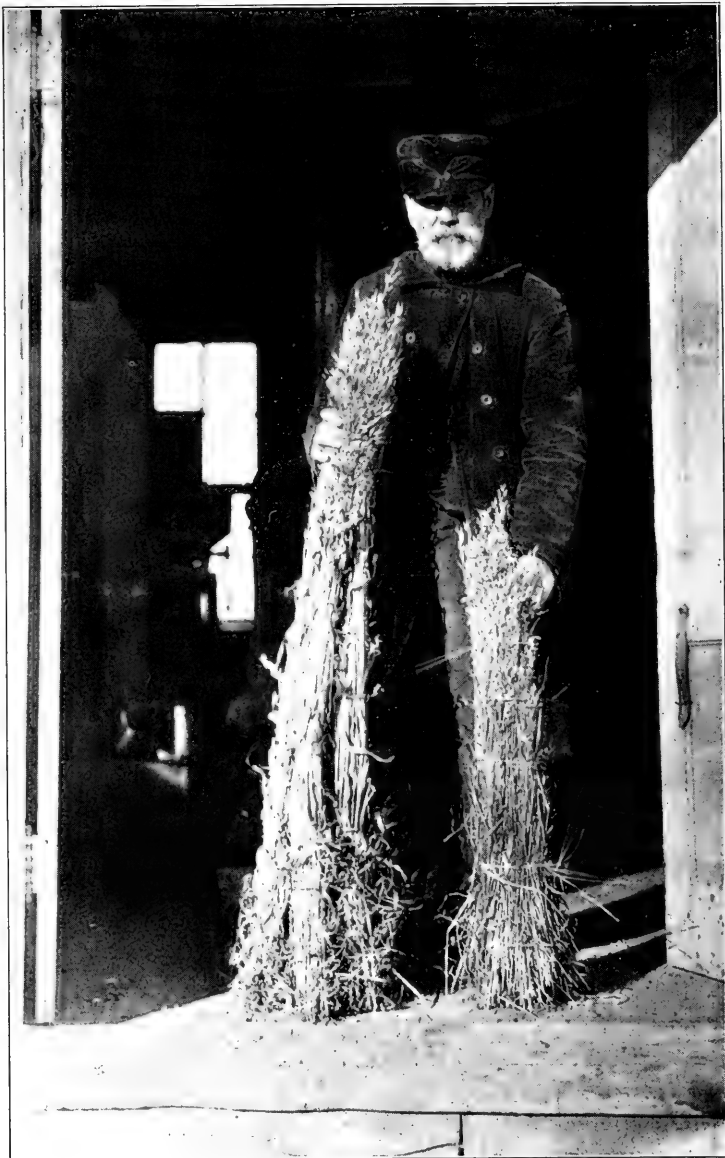


FIG. 17—RESULTS OF FANNING MILL SELECTION OF OATS.

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may be lost. It is not uncommon for some careless farmer to use four bushels of seed oats per acre, of oats that will run one million to the bushel, thus sowing about four million kernels per acre. From any such seeding no reasonable growth nor satisfactory yield is realized.

Use the Drill.

It is possible to secure rather even distribution both in broadcasting and drilling, but it is easier and safer to depend on the drill. Usually in broadcasted fields may be found many small areas where the oats are much too thick, and other areas where they are much too thin, and therefrom the yield reduced in both cases. The drill, however, in the hands of a careful man, measures out the grain uniformly, and it is placed in the ground systematically, and at regular depth, giving an even stand and a more uniform growth. It occasionally happens that drilled oats yield less than broadcasted. This is likely to be the case when too much seed is used in both cases, and probably comes from the fact that more of the oats grow when drilled, and they are thereby thicker than the broadcasted.

Treatment for Smut.

A necessary requirement for good oat crops with most varieties is that the seed be treated to destroy smut germs. An investigation of a large number of oat fields showed that from 5 per cent to 50 per cent of the stalks were blasted by smut, while in fields where the seed had been treated, practically no smut was found. Though some varieties seem quite resistant to this injury, there is probably no variety which it will not pay to treat.

There are two methods of treatment of smut—the hot-water method, and the formalin method. The hot-water method has been found to be somewhat the most efficient, but the difficulties attending its use makes the formalin method the most desirable to use. Use one pound of 40 per cent solution of formalin to about 40 gallons of water, and with this water wet the oats quite thoroughly, constantly mixing the oats with a shovel, so that all the oats receive some of the water. When well wetted, pile up the oats and cover with wet horse blankets, bags, or anything to prevent the escape of the fumes from the solution. Leave covered from 12 to 24 hours, when they may be spread out to dry, or they may be sown at once, making allowance for any increase in amount from swelling, if there be any. A thorough treatment once in three or four years is usually sufficient.

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The custom of growing very early oats or of seeding very thin are different methods of adapting the oat crop to the changing soil conditions, and the extreme of either method will not yield the largest crop.

CLOVER.

For many years red clover has been grown on Bois d' Arc farm with but two failures, and these were due to grasshoppers. For a few years before the use of phosphate was commenced, it was becoming more difficult to get a good stand on the higher and thinner parts of the fields, and some years there was a partial failure in these places. The phosphate has apparently ended the difficulty, unless the soil should become acid. Heavy seedings have been the custom. When clover was used alone the usual seeding was one bushel of seed to four or five acres of ground. Later years, because the inoculation was so thorough and the volunteer clover so abundant, slightly smaller seedings have been the rule, though a bushel of red clover, alsike clover and timothy mixed is usually used for about six acres. Clover seeding is made with oats or wheat. On the wheat it is sown early in the spring when the soil is in that checkered condition it seems likely the seed will become covered with the first rain. If this condition does not obtain, then the wheat ground is harrowed or rolled after seeding clover. When seeded with oats the seed is scattered on the surface and harrowed in.

Producing Clover Seed.

The problems connected with the clover seed crop do not seem to be well understood, and crops of only one or two bushels are the rule. On the higher land seed is produced in fair yields, but on the lower and heavier ground, the yield is very light. Clover tends more to being a perennial on such soil, but whether from this reason it does not produce more seed needs further study. Whether clover tends towards being a perennial because it does not produce seed, or whether it does not produce seed because of the tendency toward becoming a perennial is open to proof.

Some common causes of failure to secure clover seed crops are insect injuries and lack of pollination. The midge, chalcid, and caterpillar are usually in most clover fields in great abundance and are very destructive to the seed. The life habits of these insects are well adapted to the life habits of the clover, but depend on a good degree of maturity of the clover. If the first crop of clover be cut before its maturity is

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too far advanced and before the maturity of the first generation of insects that are within the heads or seeds, they are largely destroyed, and the second generation, which does the most damage, is reduced to a minimum.

On the other hand, those insects, especially the bumble bee, which aid in the pollination of clover, also have life habits which are adapted to the life history of the clover. Under natural conditions, then, the insect pests will develop the first generation in the mature first clover crop, and complete their life history in time to deposit eggs for a largely increased generation in the second clover growth, at which time the bumble bees are ready for work in the process of pollination. If clover be forced too far from its regular life habits, it may be made to avoid both the injurious and beneficial insects. If the first crop be cut too early, this may avoid the insect pests, but the second blooming period will come too early for bumble bee work. No absolute date can be given when the first crop should be cut to meet most favorable conditions in both propositions, but in the latitude of Central Illinois, this average date is about June 15, though it varies with different seasons.

It is notable that better yields of clover seed are secured from rather small fields than from large ones. This is probably accounted for from the reason that practically the same number of pollinating insects are confined to the smaller areas in their operations.

There are many species of bumble bees and with different habits as to maturity, nesting, etc. Those that nest in trees, and similar places, above ground, mature earlier than those species which nest in the ground. This may partly account for better yields of clover seed in timbered areas. Honey bees also work on clover to some extent, more especially on the lighter soils where the clover is not so rank and the flowers not so large as on the richer land. Whether bumble bees are necessary for clover pollination is frequently questioned, but observation will indicate a correlation between the two.

CROP ROTATION.

A crop rotation is desirable for many reasons, and is essential for some of these reasons. A rotation permits the growth of legume crops by which nitrogen and vegetable matter are added to the soil; it utilizes different root zones of the soil; it may include gleanings or cultivated crops; it tends to avoid insect pests; it provides for a better distribution of labor in growing, harvesting and marketing crops.



FIG. 18.—FRANK MANN'S 1911 OAT FIELD.

The most imperative of all the results that can be accomplished by a rotation, is that of the addition of nitrogen and vegetable matter from legume crops, and this also meets to a large extent those other things that are accomplished by rotation. Any rotation used should be adopted with the dominant idea of the legume crop.

The period of the rotation will depend on the soil requirements. Where nitrogen and vegetable matter are very deficient a short rotation is necessary. Mr. A. P. Schroeder has had excellent results on the poor unglaciated hill land of Pulaski county, in a four-year rotation of corn, cowpeas, wheat and clover, with both legume crops left on the land and plowed under with mineral treatments. Though this rotation has not been run many years, his average yields of grain are exceeding the average yields of the dark prairie corn belt.

Where the soil is not extremely deficient in nitrogen or vegetable matter, a three-year rotation is a good one, consisting of a cultivated grain crop, a small grain crop and the legume crop—corn, oats (or wheat) and clover. On the better corn belt land where nitrogen is not much deficient, but where the vegetable matter in the soil is so far decayed as to have insufficient activity of decomposition, and where the principal effort is to maintain and not largely increase the nitrogen, a four-year rotation will serve quite well until too much further depletion has taken place. On drained land, where the danger of heaving is not too great, a rotation of corn, oats, wheat and clover is a good one. A less desirable rotation is one of corn, corn, oats and clover, but nitrogen cannot be maintained by these rotations. On land which is not too rich in nitrogen the modified Norfolk rotation of wheat, corn, oats and clover will be better, clover being seeded with the wheat and plowed under for corn.

Whether the nitrogen is maintained or increased in any rotation will depend somewhat on the size of the legume crops, and the yield of the grain crops; and it should be the effort to adopt such rotation as will adjust the amount of nitrogen added by the legume crops to the amount of nitrogen taken out in the grain crops.

It should be well understood that no rotation in itself can maintain fertility because it cannot provide for any addition to the supply of mineral elements. If larger crops are grown under a rotation, greater drafts are made on the supply of minerals and soil depletion may go on faster because of the rotation.

WEEDS.

While weeds may serve a good purpose in conserving available plant food at a time when the ground would be otherwise idle, no effort should be spared to fight the pests. Weeds vary in their habits, so that some species become much more noxious than other, but they are all weeds. Those that propagate by means of the underground rootstocks are the most difficult to control, but a general principle can be applied to all, regardless of any special habit. It is this, that if no growth is permitted above ground, the root system must perish. The application of this principle permits of various methods, though in large areas it may be difficult of application. If a patch of Canada thistles can be deprived of all leaf growth, with a hoe or otherwise, once a week for two years, it will be practically destroyed.

One of the best aids in successfully fighting some of the perennials, and many of the annuals, is good underdrainage, as this interferes somewhat with seed germination and growth, and helps in the destruction by cultivation.

Weeds have wonderful powers of reproduction. A good crop of oats will yield about 25 to one; wheat 20 to one; corn may give 1,000 to one; but a single plant of Jimson weed has been known to produce 151,000 to one; button weed, 1,500 to one; wild lettuce 15,000 to one; purslane 1,250,000 to one; pigweed 2,359,000 to one.

There is no better place for a good sharp hoe than in the corn field after the last cultivation, and before weeds ripen. Keep the hoe sharp, and let some of the latent savage instincts of destruction have full sway. It will be a big undertaking for a few years on fields where weeds have had nearly full possession for many years, even where good cultivation has been given, and it will take years to accomplish very much towards their permanent elimination.

LIVESTOCK AND GRAIN FARMING.

No doubt in the near future there will be need for the production of more livestock. Whether that need will be met by increasing the production on that land which for one reason or another is not favorable for the production of grain; or whether it be met by using good grain lands for the purpose, is a problem that will be settled by experience. Whether a farm composed of good grain land should be used as a livestock farm, which means the breeding, rearing and feeding of animals, or whether it should be used for the production of

grain, should be determined by all the factors that enter into it, the chief factor being the man himself.

From the standpoint of soil fertility, any decision should consider certain facts that pertain to the problem. As a general average, animals appropriate one-fourth of the nitrogen in the feed for body uses, and as generally handled, another fourth is lost in the manure.

The organic matter in manure is the complement of the digestibility of the feed. Average digestibility of feed is about two-thirds, leaving one-third of the organic matter in the manure. Bedding used with manure is just as valuable to be returned to the soil in the form of straw, so far as the straw is concerned, as it is with manure. The manure has added nothing to it but manure. Notwithstanding these losses, where all the grain produced is also fed, the nitrogen and organic matter can be fairly well maintained or increased. Phosphorus must be supplied to compensate for that taken away in the bones of animals or their other products. In mixed farming where the legumes are all fed with only a small proportion of the grain, even where the manure is quite carefully saved, it seems that fully twice as many legume crops must be grown, than where the legume crops are plowed under, and nothing removed but the seed, in order to maintain nitrogen and organic matter, and it also requires that more phosphorus be applied.

Land may be so poor in nitrogen and organic matter that it is more profitable to grow frequent legume crops and turn them under than to feed stock, when the desire is to rapidly build up such a soil. In fact, it would seem that the richest land is the land that can best be used for the purpose of a stock farm, except such land as can not be used for any other purpose.

WHAT TO DO WITH THE CORN STALKS.

The use of corn stalks for feeding purposes involves more hard, disagreeable and less profitable work than any other method of feeding. Where the whole crop is fed in a natural condition for the primary purpose of the grain, with stalks for incidental roughage, and the crop harvested and handled in some economical manner, it may prove a fairly satisfactory method of feeding. Where the corn is husked and the stover is fed in a natural condition as a substitute for hay, it involves much disagreeable and hard work, in husking the corn, hauling the fodder and returning the manure to the field. There is probably no job that is more disagreeable than handling

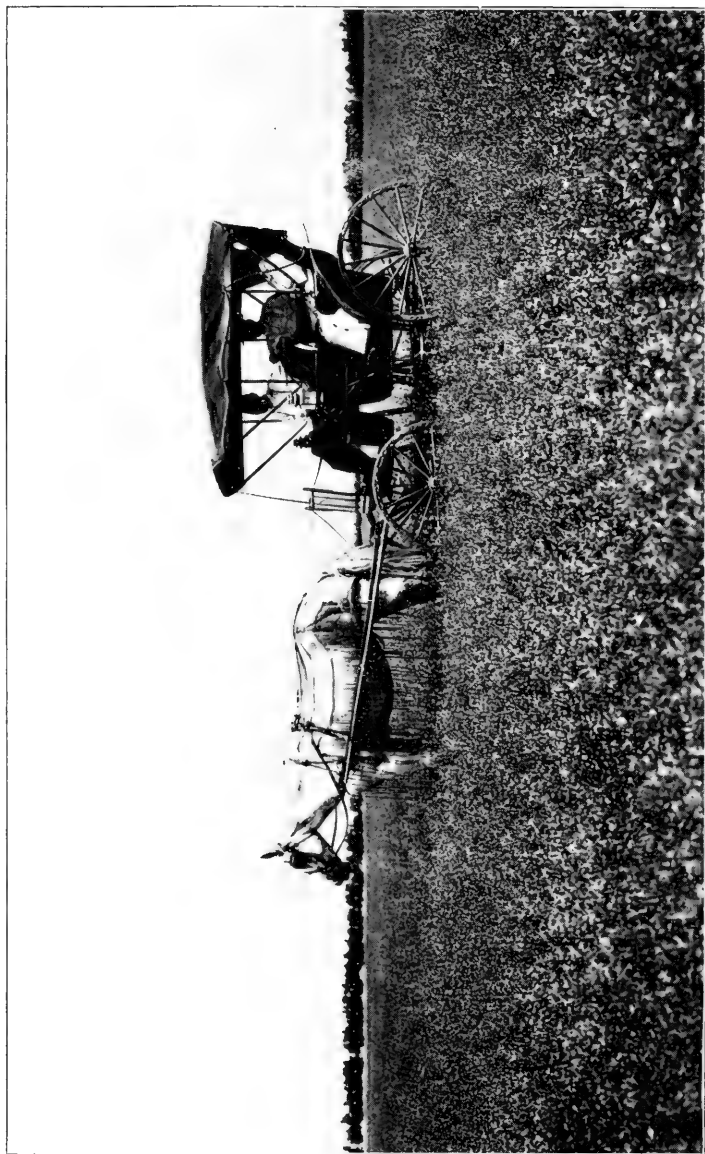


FIG. 19.—SECOND CROP OF ALFALEA ON FRANK MANN'S FARM JULY 9, 1911.

manure made from long corn fodder. The use of machinery to husk the corn and shred the fodder is not likely to lessen the expense very materially. Shredded fodder has a high tendency to heat and spoil, and usually it is not safe to pile up much of it before late in November, and even after that time it rarely keeps well in large quantities. By the time it is usually safe to shred corn the days are short, and it is likely the shocks are either frozen in the ground and covered with snow, or the fields are wet and soft, and the operations are slow and expensive; and the shredded fodder is dirty and gritty.

When we consider that the feeding value of two to three acres of average corn stover is less than one ton of alfalfa hay, and not considering the loss that comes from the shrinkage in the corn, nor the value of the undigested fodder as humus; it would seem that alfalfa would entirely supersede corn fodder for stock feeding. Especially so since more feeding value can be produced on one acre of alfalfa than on 10 acres of corn stover, and the labor and expense involved is much less.

Advantages of Silage.

The use of the corn crop in the form of silage meets every objection that has been used against the feeding of fodder. The work is done at a time when economical work can be done; the bio-chemical changes that take place in the silo increase the palatability and digestibility of the feed; the feed is easily accessible at all times, and is easy to handle both as a feed and in the manure. One great value of silage is as a supplement to summer pasture, and when there is not enough to feed the whole year it usually pays to feed less in the winter in order to have some for summer feeding. Cows trained to it will never get so full of anything else that they will not eat ensilage.

The Pearl pop corn has been used for silage for a number of years on Bois d' Arc farm, and is a favorite. It yields nearly as much silage as field corn, with about the same proportion of grain, and is more easily handled both in the field and by the machinery, and there is somewhat less waste in feeding, as compared to large stalks of field corn.

ALFALFA.

Alfalfa has been grown on Bois d' Arc farm for 11 years, with an average annual yield of 5 tons per acre. It has been demonstrated in that time that successful growing depends on soil inoculation; a sweet soil, or the soil sweetened with

limestone; and good natural drainage. Alfalfa may grow without inoculation and on an acid soil, but the growth will only be so much as the soil nitrogen will produce, and when more nitrogen is required for growth, if it cannot be secured through the action of the nitrogen-gathering bacteria, the alfalfa plants will perish.

Alfalfa is a heavy user of phosphorus, and before the alfalfa field is plowed up for other crops, it should be given a heavy application of phosphate. Alfalfa does not injure the soil for other crops, as can be seen from results given in another place.

The day has gone by when the dairyman and stock grower can realize much profits from the old methods of feeding principally the corn crop, supplemented by some high priced protein mill feed. He has at hand a system that will prove far more profitable by growing protein in alfalfa and using the corn crop as silage.

ROTTEN CORN.

Because of the great amount of corn grown and the length of time it has been grown, it is remarkable that there has not been some insect pest developed that would be as disastrous to the corn crop as are some of the pests to other crops. Most of the insect pests of corn that we have are quite readily controlled by easily applied methods, due to the diligent study of the problems by the entomologists. A disastrous enemy to corn which has existed for many years, and which is becoming more prevalent and injurious as the years go on, is the dry rot of corn. It is possible that this trouble may in the future prove a much greater handicap to both the yield and quality of corn. It is well understood that the disease is caused by fungi of the *Diplodia* and *Fusarium* species, with occasionally some bacterial injury. When the disease attacks the ear early in its period of growth, there is likely to be an undeveloped ear, and sometimes but little more than a cob. At husking time ears are found that were arrested in growth at all stages of development. Some ears show but slight progress of the disease and that the ear almost reached full maturity. Some ears show but a slight infection, as shown by the discolored cob at either the butt or tip end, according as to whether the infection came from the shank or silks. Though there may be many ears where the mould has apparently destroyed the whole ear, and its appearance is only a bunch of mould, probably the greatest loss comes from the shrinkage in weight and quality of those ears which do not show much mould.

The habit of the fungus is to extend the mycelium (roots) throughout the growth, especially the grain, and abstract therefrom the nitrogenous matter, leaving the starch. Thus in consuming the most vital parts of the kernel, any ear that has the slightest infection, as shown by a discolored cob, is unfit for seed purposes. An infected ear is rarely a mature ear. It may have the general appearance of perfect maturity, but the soft and spongy cob will show otherwise. Whether the disease is the cause of immaturity; or whether the lack of maturity is the cause of the disease, is open to proof for either contention. It is a fact that the diseased ears are not mature, and that very few immature ears are free from some degree of infection.

It is generally considered that the dry rotten corn was due to some condition of the weather: that a humid atmosphere and high temperature were responsible for the trouble. But the season of 1911 was the driest for many years; when there were but few humid days, and no heavy rainfall throughout the growing season, and there is more rot in corn than ever before. While the nature and technical causes of the disease responsible for rotten corn have been studied, not much effort has been made towards learning the measures of resistance. It does not seem to be due to constitutional reasons, as several years breeding seems to have but little effect against it. Observation and definite information secured for several years show that the disease is influenced by a better balance in the supply of the elements of plant food. It has been noticed that the rotten corn is more abundant when corn is grown on clover sod, where nitrogen was likely to be in excessive amounts as compared to other elements. This does not, however, conform to the belief that the corn stalks, etc., of the previous year are necessary sources of infection.

When a high nitrogen soil content is even partially balanced with phosphorus the effect on the disease is material. Several hundred hills from clover sod where no phosphorus had been applied, were examined with reference to infected ears, and all ears showing any infection, even to a stained cob, were counted; an equal number of hills was examined from a nearby part of the same field, to which one ton of phosphate had been added. No corn had been grown in this field for four years previous. From the untreated ground the corn that showed more or less of the disease was 40 per cent of the crop; from the treated ground the infected corn was but 15 per cent of the crop.

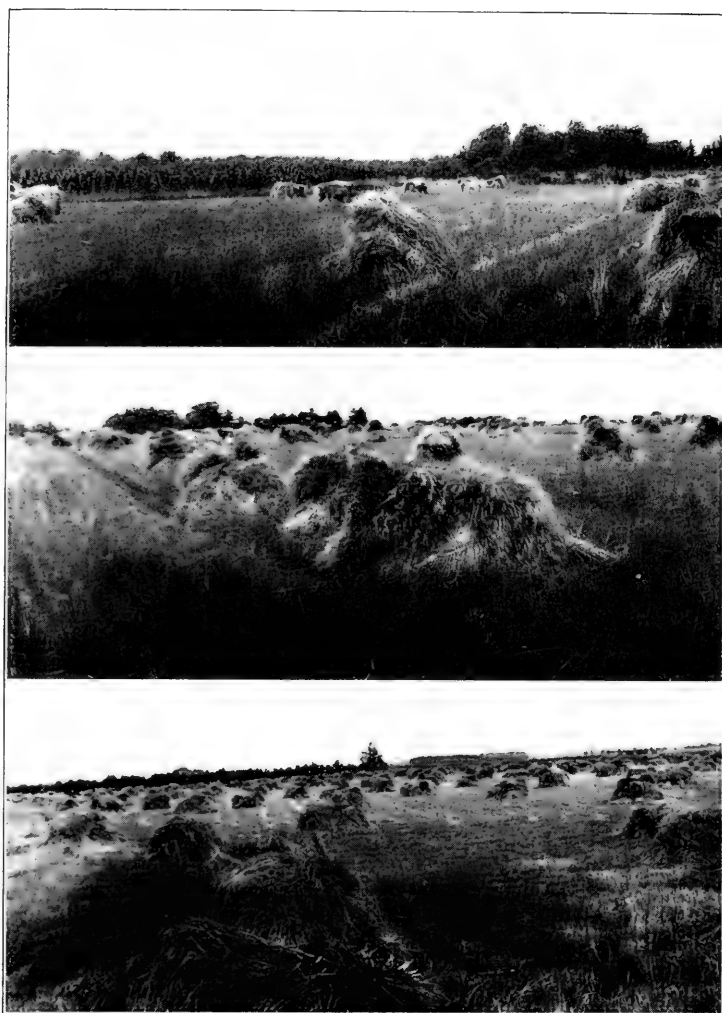


FIG. 20—WHEAT ON UNTREATED LAND, 35 BU. PER ACRE.
TREATED WITH ONE TON ROCK PHOSPHATE, 50 BU.
TREATED WITH $1\frac{1}{2}$ TON PHOSPHATE, $52\frac{1}{3}$ BU.

Corn having the dry rot has been fed more or less for years without any apparent injury to any kind of stock, but it has always been fed in connection with some highly nutritious and nitrogenous food. When the fungus has quite fully developed there remains but little of anything but the starch, and such corn makes a ration so far out of balance for animals, as to be a probable cause for numerous ailments. Such ailments should not be confused with the regular corn stalk disease, which probably is bacterial, and is not caused by the grain.

SUGAR BEETS.

Good crops of sugar beets have been grown on Bois d' Arc farm, and there is no question as to the ability of the soil to produce good crops of beets having a high sugar content. Growing sugar beets is essentially a labor proposition. Much of the labor required is due to the pernicious activity of that most abundant weed of the corn belt—the crab-grass. In regions where this weed abounds and where labor is also scarce, there is nothing in sugar-beet culture that commends itself to corn belt farmers.

Extravagant claims are sometimes made as to the effect of beets on soil fertility; that as sugar is only "wind and water" no draft is made on soil elements in its production. It is true that sugar contains no fertilizing elements, and where only the sugar is marketed and all residues left on the farm, as is the case on some of the German estates, no fertility leaves the farm, though there may be losses of fertilizing elements from feeding and handling. The case is different, however, when the beets are shipped to a factory and the residues not returned to the land, as an average crop of sugar beets will remove as much of the elements of fertility from the soil as an average crop of corn.

It is also claimed that part of the compensation of growing sugar beets is realized in other crops that follow the beets. No doubt sugar beet ground is in fine physical condition for other crops. Probably most of this is due to the late fall plowing that is necessary in digging the beets, as well as to that part of the deep root system that remains in the ground. The beets themselves have no power to add any elements of fertility. It does not seem that any benefit that could accrue from a sugar beet crop to succeeding crops, would not also more largely accrue from a clover crop; and the clover crop would also have a further advantage of supplying nitrogen.

THE VEGETABLE GARDEN.

There is nothing from which so much might be gained in the way of health and economy, that is so much neglected as the farmer's vegetable garden. Much of this neglect is probably because the soil of the garden is in bad physical condition and works up soggy and cloddy; and it is also often the weediest spot on the farm. Such a condition requires so much hard work to grow a little poor garden stuff that it is easier to let most of the garden go by default.

If the garden be divided into two or three parts, and one part be used for the garden and the other parts be seeded to clover, and thereafter the garden portion be rotated with the clover portion, more and better garden stuff could be grown with very much less work. On most soils, if the clover portion be plowed late in the fall it would provide the proverbial "ash heap" for a garden by spring. While in clover, as much manure may be applied as is desired and the trash will not be a nuisance by the time that portion becomes the garden part.

Concentrate the garden by planting the rows close together, say, an average of 12 inches apart, sandwiching the rows of small early stuff between rows of larger and later articles. When the garden is planted, sharpen the hoe well and hang it up, and get the hand wheel cultivator, with which nearly every weed can be kept down. An hour or so every week on clover sod will keep every weed out of a garden large enough for a large family. It is best to plant those things grown in larger quantities, as potatoes, or that occupy much ground, as pumpkins, in some other place where they can be cared for with horse tools.

BOIS d' ARC WOOD.

No one knows the durability of the osage or Bois d' Arc wood. Hedge stakes that measured less than one and one-half inches in diameter, set in the ground in 1868 for grape stakes, have stood in a blue grass sod for many years, and are now apparently as sound as ever. Wagon wheels made of osage in 1866 are still in use, though having worn out two sets of tires, nor did the tires need resetting until worn thin. As posts, it is not possible to speculate as to the durability of this wood.

Where no conditions would tend to prevent it there may be some profit in permitting the old hedge rows to grow for posts. If the roots are quite well established ten years' growth will make very satisfactory posts. If the cutting should give

1,600 posts from an eighty rod row, at a price of 20 cents each, and calculating the hedge row to occupy two rods wide, the returns, exclusive of labor, would be \$320 for one acre for ten years, or \$32 per acre annually. These figures may be adjusted to different conditions, and there will remain fair prospective profits. Osage posts have no competitor for durability except the cement post.

To grow good posts in a hedge row, the hedge should be permitted to grow for several years without any trimming, or until the posts have grown straight and are strong enough not to bend over under the weight of the top. After this, the row should be kept trimmed on the sides, and the crooked and undesirable stakes cut out. When the row is made up into posts it is a good plan to throw the posts into a pond of water and leave them there for a few months to let them water cure. If so cured they are not eaten by borers, nor injured by check cracking, and the staples hold better.

A wonderful demonstration in post growing is being conducted by Hon. A. N. Abbott, on his farm in Whiteside Co., Ill. He is growing large areas of black locust trees on some dune sand that is too poor to grow anything but legumes. The locust being a legume secures its own nitrogen, and is proving a valuable crop on the poor sand.

FARM LABOR.

This is not intended to be any solution for the scarcity of competent farm labor, which is due to some wide economic conditions that cannot be solved so easily. There is need of competent labor to be transferred from the cities to the country, and only such as can be termed good is wanted, nor will any other succeed. But this class of workers in the city have been accustomed to business hours and business habits, and can see nothing attractive in farm life, where during the hired man season, every thing is hurried from sun up till sun-down, as it once was. To work from dark to dark is not business, nor does it pay. Neither men nor horses can stand it if good work is to be done all the time. In a day of nine or ten hours in the field, with but few chores to do before and after, men and teams will accomplish more good work, and the men can feel like human beings, and the horses can feel their oats. If more brains were put in the business there would be less need for muscle and such long hours.



FIG. 21—ONE OF FRANK MANN'S FIVE YEAR OLD HEDGROWS.

GETTING RID OF GRASSHOPPERS.

Reprinted From *Prairie Farmer*, September 1, 1911.

What would you consider a good yield of grasshoppers per acre?

Most central western farmers are getting a good deal larger yield this year than they would like, but few have taken the trouble to harvest them. Frank I. Mann of Gilman, Ill., believing that there is no good grasshopper but a dead grasshopper, recently harvested and buried a large share of his hopper crop. In fact, things had about come to the point where it was necessary to harvest the grasshoppers or have nothing else to harvest. A 55-acre clover field that was being saved for seed looked as if it would all have to go for grasshopper pasture. In the alfalfa field the hoppers did not even give the buds a chance to unfold, but ate them off as fast as they appeared. Another week would have finished the alfalfa plants entirely.

This was the condition when Mr. Mann started his grasshopper harvest. The result of that harvest was 50 bushels of hoppers from the 55-acre clover field, and 10 bushels from the 20-acre alfalfa field. The total yield of hoppers was nearly a bushel to the acre on the clover field and half a bushel on the alfalfa.

How to Make a Hopperdozer.

Mr. Mann's grasshopper harvester, or hopperdozer, is built as follows: The front of the machine is a pole about 18 feet long. Extending back from this at each end and in the middle is a runner about three feet long. A platform is built on these runners. Just behind the front pole are placed a number of galvanized iron pans, about four inches deep. The pans altogether are 16 feet long and about 2 feet wide. Behind these pans, and at each end, is a four-foot backstop of galvanized iron. This backstop slopes forward somewhat. Two or three inches of water is placed in the pans, with a thin film of kerosene on top. The object of having small pans instead of one large one is to keep the liquid from running to one end or splashing out. A horse or team is hitched to each end of the pole and the grasshopper harvester drawn through the clover or alfalfa field.

The best time to harvest hoppers is on a warm sunshiny day, as they will not hop well in cold or damp weather. When the hoppers are disturbed by the approach of the machine they hop in whichever direction they happen to be headed. About half of them will jump backward, hit the

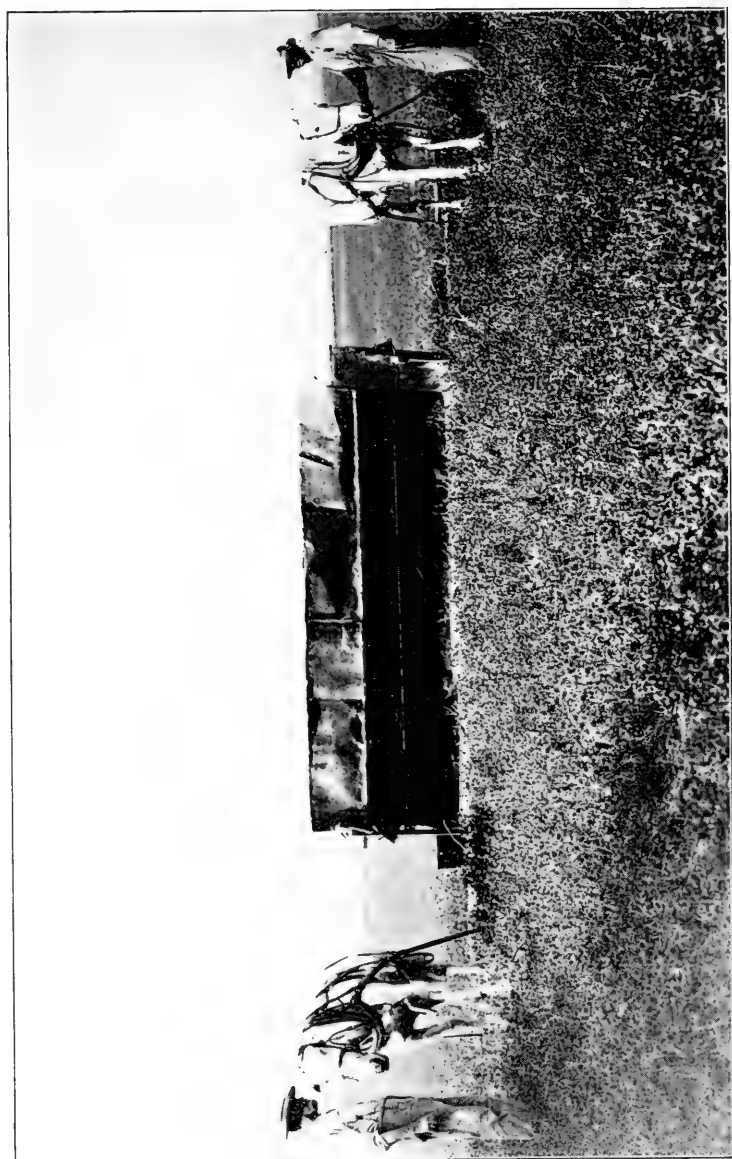


FIG. 22—HARVESTING GRASSHOPPERS ON FRANK MANN'S FARM.

backstop, and fall into the pans. A few of them will hop out again, but they never survive their kerosene bath. Those that hop ahead are caught later.

In some cases one trip over the field will reduce the hoppers enough so that they will do little further damage. Sometimes it may be necessary to go over parts of the field again. The hoppers congregate where the clover is thickest, so that often this is the only part of the field that needs to be gone over. With a team on each end of the machine 20 acres of hoppers can be harvested in a day. Aside from the labor the only expense will be the cost of about five gallons of kerosene.

Within two weeks after the grasshopper harvest Mr. Mann's alfalfa grew eight inches, and his clover recovered enough to make considerable seed. It is only occasionally that grasshoppers are plentiful enough to do any great amount of damage. The common red-legged grasshopper is subject to fungus diseases and insect parasites that usually keep it in check, but occasionally they get the start of these enemies, with disastrous results to crops.

The Grasshopper's Life History.

A word in regard to the life history of the grasshopper may be of interest. The female hoppers lay their eggs in September, always choosing hard ground, such as meadows, pastures or fence rows. They bore round holes in the ground with their abdomen, laying a mass of eggs in the hole. The eggs are encased in a layer of mucus, which protects them. It takes the female hopper three or four hours to deposit a single mass of eggs. Ordinarily each female will deposit from two to four such masses. None of the adult hoppers live through the winter. The eggs hatch in early midsummer. The small hopper, or nymph, is much like the adult insect in form. The skin or outer covering of the little hopper is hard and cannot expand. The little fellow grows until he cannot pack himself any more tightly into his skin. Then the skin splits open, and the hopper grows to almost double his former size in a few moments. His skin soon hardens again, and the growing and molting process is repeated. The hopper passes through five successive molts before it is full grown and develops its wings. The red-legged grasshopper is not migratory like the Rocky Mountain locust that sometimes does so much damage in the west.

Disking alfalfa or pasture ground in the fall will break up the egg masses and expose them to birds and other ene-



FIG. 23—HOW THE GRASSHOPPER HARVESTER IS MADE.

mies. Grasshoppers are so seldom troublesome, however, that the best method of handling them is to harvest them with a hopperdozer when they become so thick as to do much damage.

A HOME-MADE PHOSPHATE SPREADER.

BY FRANK I. MANN.

Reprinted From *Prairie Farmer*, September 1, 1911.

The following is a bill of material and details of different parts for a machine for distributing fertilizers. By having the different iron parts made at a blacksmith shop, any one with a few tools can make the wood parts and assemble all the parts into a machine. This is for a machine that will spread eight feet wide, and is taken from a machine that has been used quite successfully for several years. A wider machine can be made on the same general plan, but the swing on wider machines makes the extra width of doubtful value.

The Materials Necessary.

Bill of material—2 1-in.x10-in.x10-ft. boards; 2 1-in.x12-in.x10-ft. boards; 3 4x4x8-ft. 8-in.; 2 4x4x44-in.; 1 4x4x3-ft. 6-in., hardwood; 2 2x4x4-ft. 2-in.; 1½-in. square shaft 7 ft. 2 in. long; 4 ¼x1-in. iron 7 ft. 10 in.; 20 ft. ¼x1 in. strap iron; heavy sheet iron 7 in.x8 ft.; heavy sheet iron 3 in.x8 ft. 6 in.; 2¼x¾x8 ft. 6 in. strap iron; 1 piece wagon tire 4 ft.; 1 5-16 in.x8 ft. round iron; mower wheels with ratchet and shaft; disc trucks.

Iron work—Weld piece of round mower shaft to each end of square 1½ in. shaft, so that no more than 7 ft. 10 in. is left square; put on mower wheels so that the hub containing hole to rivet to shaft is on the outside or next to end of shaft; set wheels so the distance between inside hubs is 8 ft. 9 in.; drill hole in shaft to match hole in hub of wheel, having each wheel equally distant from square part of shaft.

Just How to Make the Parts.

Make 16 pieces out of ¼x1-in. iron; each piece 4 in. long, distance between centers of holes 3½ in., with holes 5-16-in.; shoulders to be 1½ in. apart and 3-8 in. deep to fit on square shaft in pairs with ¼ in. strap between. Drill 5-16-in. holes in two ¼x7 ft. 9 in. straps 3 in. from each end, and two holes equally distant between.

In the other pair of ¼x7 ft. 9-in. straps drill holes 4½ in. from each end, with two holes equally distant between. Put clamps on shaft and bolt on straps with 5-16 in. bolts, 1¼ in. long.

Make hopper box 22 in. high, 5 in. inside at bottom and 2 ft. wide on top. In each end bore hole for shaft to center $2\frac{1}{2}$ in. from bottom of hopper. One end of hopper should be bolted into place or temporarily nailed, as shaft with reel must be put in place before end is fastened permanently.

Construction of the Hopper.

The bottom of hopper and slide make of the sheet iron pieces. The sheet iron 7 in.x8 ft. should be heavy, even up to 3-16 in. thick, but the 3-in. piece need not be so heavy.

For temporary purposes rivet the two pieces together, the narrow piece in the middle of the wider, and even at one end. Mark out for holes about 8 in. between centers, with end holes 4 in. from each end of hopper box.

With a 1-in. drill drill two holes as close together as possible, then chisel and rasp out till there is a smooth hole 1 in.x2 in., the length of the hole being with the length of the hopper. Separate the two pieces of sheet iron and drill a few screw holes in the edge of the wider piece, and fasten to the bottom of the hopper box with screws.

On each side of the bottom is fastened a strip of wood $\frac{7}{8}$ in.x $\frac{3}{4}$ in., fastening with nails through the screw holes into the side of the hopper box. These two pieces should be just far enough apart to leave room for the cut-off slide. Four pair of straps similar to wagon box straps 2 ft. long, rounded and threaded about 2 in. at one end, should be bent to fit the hopper, extending an inch below the bottom piece.

Four pieces made from old wagon tire, with $2\frac{1}{2}$ -in. holes 7 in. apart, with a piece $\frac{1}{2}$ in.x3 in. riveted to the middle. This piece should fit on the box straps, and will be the support of the cut-off slide.

The cut-off slide should be reinforced by riveting on each edge $\frac{1}{4}$ x $\frac{3}{4}$ in. iron strap; 3 ft. 4 in. from left end is riveted a piece of iron that will project forward past the box about 2 in.

Hard Wood for the Shaft Boxes.

A partial partition can be placed about the middle of the box, and rods made of 5-16 in. iron can be put at each end and in the middle to hold box well together and so make more substantial.

Boxing for shaft can be made of any hardwood, but osage is the best. Make boxes about 4x4x1 ft. Bore hole to fit shaft and fasten the boxing temporarily to each end of hopper box, having hole in boxing match hole in hopper. Bolt 4x4x44-in. on boxing to extend 4 in. to rear of hopper, and bolt hopper box to this 4x4.

Fit and bolt 4x4 on rear of hopper, and also on front, but first cut a place for lever 42 inches from left end about 6 in. wide and 1 in. deep. Complete frame by bolting 4x4 on front end of the side 4x4's and bolt hardwood stub tongue in middle of frame, and using the 2x4's for braces to each end of box. Attach common disc truck to stub tongue. Make hand lever from wagon tire, 3 ft. long with rounded handle at one end and fork at other end to fit gudgeon on cut-off slide; drill hole 13 in. from fork end and fasten lever with bolt through 4x4 frame at notch in same.

A 10-in. board nailed on front side of top of hopper can be used by driver. A piece of sheet iron can be notched and fastened on top as a guide to the lever.

Capacity of the Machine.

When wide open this machine will spread one ton per acre, and when half open will spread 1,000 pounds phosphate per acre. However, the amount spread varies somewhat with fineness of grinding, speed of horses, manner of handling material, etc.

Enough material should be kept in the machine all the time to keep reel covered. It is necessary sometimes to remove the cut-off slide and clean out the material that works in between the slide and bottom of box. If it is desired to spread more than one ton per acre, the holes can be increased in length. Four in. holes will spread about three tons per acre.

After reading the foregoing directions, Dr. Cyril G. Hopkins of the University of Illinois makes two suggestions. One of these is that the machine should be made to cover a strip 8 feet 3 inches wide, which is exactly one-half a rod, so that one round on a half-mile land, or two rounds on an 80-rod land covers exactly one acre. It may be that Mr. Mann counts that his machine, although made only 8 feet in length, will really spread phosphate over 8 feet 3 inches. It is a minor point, but it is very satisfactory to the farmer to have everything made so it helps him to measure the acres as he covers them.

The other point is to make the directions such that the machine will be made with the holes large enough so that it can be set to sow three tons instead of only one ton. There would be no disadvantage in having the machine made to have a large capacity and adjustable, as it is, for any smaller capacity.

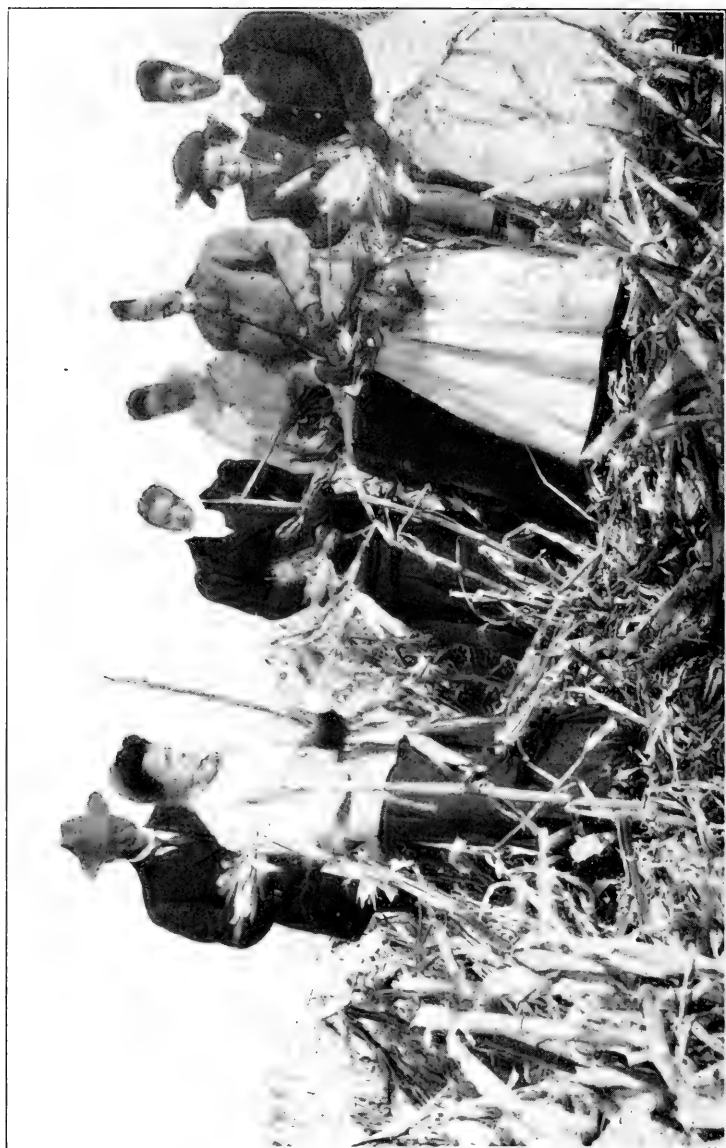


FIG. 24—A CORN HUSKING PARTY ON BOIS D'ARC FARM.

SCIENTIFIC FARMING ON FRANK MANN'S FARM.

Reprinted from *Prairie Farmer*, August 1, 1911.

Frank I. Mann's farm at Gilman, Illinois, is no place for a pessimist. The sight of the crops that are growing there would be too much for him. Like the pessimist in the story, he would have to fall back on the argument that such crops are "powerful hard on the soil." That is just what Mr. Mann has foreseen and provided for, however, and therein lies the secret of his success.

Thirty-two years ago Mr. Mann started farming on 500 acres of what was then almost virgin prairie. Two years later he began a regular four-year rotation of corn, oats and clover, which he has followed as closely as possible ever since.

Mann has Tried Everything.

To use his own words, he "has tried everything in the art of farming—deep plowing and shallow plowing, double discing and late cultivation and every other method of soil handling that might have an effect on the yields." Still he was unable to get the yields up to a point that satisfied him, for like Julius Cæsar, he was ambitious. Even the manure from his dairy herd did not bring the desired results, although it helped in that direction.

Something was lacking, and Mr. Mann, who by the way, is a graduate of the University of Illinois, and goes at his problems as scientifically as a skilled physician or a railway president, began to inquire what it was. As a result of these inquiries he began to apply ground rock phosphate and his yields have been going up ever since. Where they will stop it is impossible to predict.

One Limiting Factor.

There is always at least one factor that is limiting the yield of farm crops. Mr. Mann makes it his business to discover and eliminate that factor so far as possible. At first the limiting factor was phosphorus. He plans to treat each field with four tons of phosphate rock to the acre just as fast as he can make the rounds. He figures that this will take care of the phosphorus supply for many years to come with occasional slight additions. This treatment will cost about \$30 per acre—add that much to the cost of his farm, in other words. To return 5 per cent interest on this additional value will require no more than 4 bushels of corn or two of wheat per acre per year. This year a part of the wheat field that had been left untreated yielded 17 bushels less than the treated part. As



FIG. 25—HARVEST TIME ON BOIS D'ARC FARM.

time goes on the difference will become greater, as the phosphorus supply of the untreated acre grows less.

Cost of Fertility Small.

After the four tons of phosphate rock per acre are added, one cent for each bushel of wheat sold and half a cent for each bushel of corn will maintain the phosphorus supply. Clover and manure, and to some extent alfalfa, supply the nitrogen and organic matter. A little ground limestone occasionally will keep the soil sweet. The best of cultivation is used to make this fertility available. This cultivation, which begins early in the spring, and lasts, in the case of corn, until late in August, when conditions demand it, also helps a great deal to conserve moisture. Moisture is the limiting factor in a great many fields this year. On July 8, when many neighboring fields were firing badly, Mr. Mann's corn showed very little damage. This notwithstanding the fact that it was almost twice as big as much of the surrounding corn, and hence had used twice as much moisture. The corn ground is often disced half a dozen times before planting time. After the corn is too big to straddle, one-horse cultivators are kept going between the rows until after the corn is eared out. Any weeds that escape this severe treatment are chased down by men with hoes, as Mr. Mann does not believe in sharing his plant food and moisture with weeds.

Corn Breeding Plots.

With an abundance of readily available plant food the limiting factor often becomes the yielding ability of the particular variety of seed that is used. The remedy for this is scientific breeding. Mr. Mann maintains 96 ear-rows by which to select high yielding varieties of corn. "I do not consider anything but the yield," he says. "If nature can produce more corn on a tall stalk than on a short one, or more with a broad kernel than with a deep one, I'm going to let her do it."

Mr. Mann is modest when it comes to speaking of yields. The phosphate treatment has increased his corn yields 15 bushels per acre, his oat yields 20 bushels and his clover one ton. Last year his best treated corn field yielded 87 bushels per acre, and this season he obtained an average wheat yield of over 52 bushels from $7\frac{1}{2}$ acres.

The Result of Science.

But, after all, it is not large yields that make Mr. Mann's work remarkable. Other men by one means or another have



FIG. 26—HOW INVENTION HAS LIGHTENED THE HIRED MAN'S BURDEN.

now and then obtained yields as large. The results which Mr. Mann has achieved are remarkable because they come as the result of scientific study. "I am satisfied that I could take almost any farm in the state and by studying the soil and giving it the proper treatment build it up to the same point," he says.

This is the new idea in agriculture—the Illinois idea, we might say, for nowhere else has it been promoted so persistently as in Illinois, and nowhere else are the farmers taking hold of it so enthusiastically. To prepare and handle soil and seed so as to produce three or four times average yields, to do it continually year after year, and to make the soil more fertile in the process—this is an agricultural ideal worth working toward, an ideal that agricultural nations all through history have been struggling to reach. This is the significance of the work of Mr. Mann and of the other farmers in the state who are working along similar lines.



FRANK MANN'S SOIL BOOK

THE PRAIRIE FARMER'S CREED.

I believe in red clover, I believe in cow peas, I believe in soy beans, and above all, I believe in alfalfa, the queen of forage plants.

I believe in a permanent agriculture, a soil that shall grow richer rather than poorer from year to year.

I believe in hundred bushel corn and in fifty bushel wheat, and I shall not be satisfied with anything less.

I believe that the only good weed is a dead weed, and that a clean farm is as important as a clean conscience.

I believe in the farm boy and in the farm girl, the farmer's best crops and the future's best hope.

I believe in the farm woman, and will do all in my power to make her life easier and happier.

I believe in a country school that prepares for country life, and a country church that teaches its people to love deeply and live honorably.

I believe in community spirit, a pride in home and neighbors, and I will do my part to make my own community the best in the state.

I believe in better roads. I will use the road drag conscientiously whenever opportunity offers, and I will not "soldier" when working out my road tax.

I believe in happiness, I believe in the power of a smile, and I will use mine on every possible occasion.

I believe in the farmer, I believe in farm life, I believe in the inspiration of the open country.

I am proud to be a farmer, and I will try earnestly to be worthy of the name.

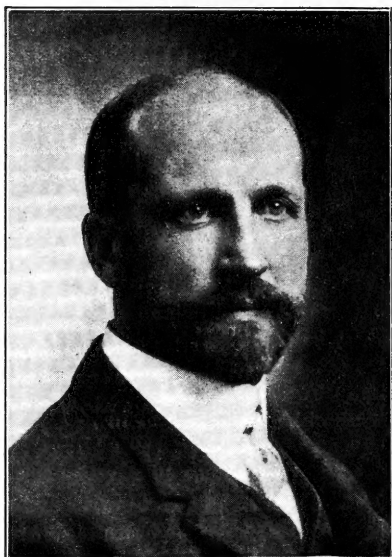
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